Annexures

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Annexure A

Watercourse Assessment

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BOWDENS SILVER

ABN: 37 009 250 051

Bowdens Silver Project

Watercourse Assessment

Prepared by

R.W. Corkery & Co. Pty Limited

January 2020

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ABN: 37 009 250 051

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Watercourse Assessment

Prepared for:

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GLOSSARY OF COMMONLY USED TERMS AND ACRONYMS

AHD	Australian Height Datum.
AMTD	Adopted Middle Thread Distance: measured from the outlet (mouth) of a given watercourse.
ANZG	Australian and New Zealand Guidelines
ARMCANZ	Agriculture and Resources Management Ministerial Council of Australia and New Zealand
Bed Aggradation	Channel bed is accumulating sediment
BoM	Bureau of Meteorology
Box and Whisker Plot	A method for graphically depicting statistical groups derived from numerical data. The boxes depict variability within a given percentile range (20th and 80th) that is considered to be within the range of temporal and seasonal variability (ANZG) whilst the whiskers present the variability outside of the range of temporal and seasonal variability.
BSW	Bowdens Surface Water
Left Bank	Left hand bank of a watercourse when viewed looking downstream
NWQMS	National Water Quality Management Strategy
RCP	Reinforced Concrete Pipe
Right Bank	Right hand bank of a watercourse when viewed looking downstream
SILO	Scientific Information for Land Owners
TSF	tailings storage facility
Unregulated Watercourse	A watercourse that is allowed to freely discharge due to the absence of substantial hydraulic controls having been placed in its flow path (i.e. dams or weirs)
WRE	waste rock emplacement

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1. WATERCOURSE CONDITION ASSESSMENT

1.1 BACKGROUND

The watercourses within and surrounding the Mine Site are situated predominantly within the Hawkins Creek sub-catchment of the regional Lawsons Creek catchment. Hawkins Creek drains in a south-westerly direction prior to entering Lawsons Creek approximately 0.8km south of the Mine Site (**Figure 1**). Lawsons Creek generally flows in a westerly direction prior to entering the regulated Cudgegong River at Putta Bucca, approximately 1.6km north of Mudgee and approximately 26km west of the Mine Site.

RWC and Bowdens Silver personnel conducted physical inspections of the subject watercourses during the period between 17 July 2017 and 19 July 2017 and 23 May 2019. The purpose of the physical inspections was to establish the physical condition of each watercourse and place them into a geomorphologic context.

Water quality data collected over the period between June 2012 to November 2018, was assessed and subjected to exploratory data analysis via statistical interpretation recommended in Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) and graphically using box and whisker plots. This type of plot is extremely useful in providing a visual representation of the statistical interpretations for condition assessment. All plots present data as maximum, minimum, median, 20th and 80th percentiles with the median value chosen for comparison to trigger values. This is the current approach recommended in ANZG (2018).

An important factor in the assessment of future water quality in the watercourses downstream from the Mine Site would be the chemical composition of runoff from the structures and landforms constructed around the perimeter of the Mine Site. Those structures would comprise the TSF embankment, the southern barrier, oxide ore stockpile and the noise barrier and lower embankment haul road around the WRE. Given these structures would be constructed using non-acid forming (NAF) waste rock, this report includes a brief summary of the likely runoff water quality from these structures and landforms, drawn principally from the results of leachate testing on:

- NAF waste rock by Graeme Campbell & Associates (2019); and
- Stream sediments.

1.2 METHODOLOGY

The subject watercourses were identified based on their location and position within their respective catchments with respect to the principal components of the Bowdens Silver Project (see **Figure 1**).

The watercourse inspections were used to:

- identify the physical features present at the inspection locations (see **Figure 2**);
- identify the origin and development of the watercourse over time; and
- subsequently establish the geomorphic characterisation of each watercourse,

Figure 1 Indicative Mine Site Layout and Catchments Boundaries

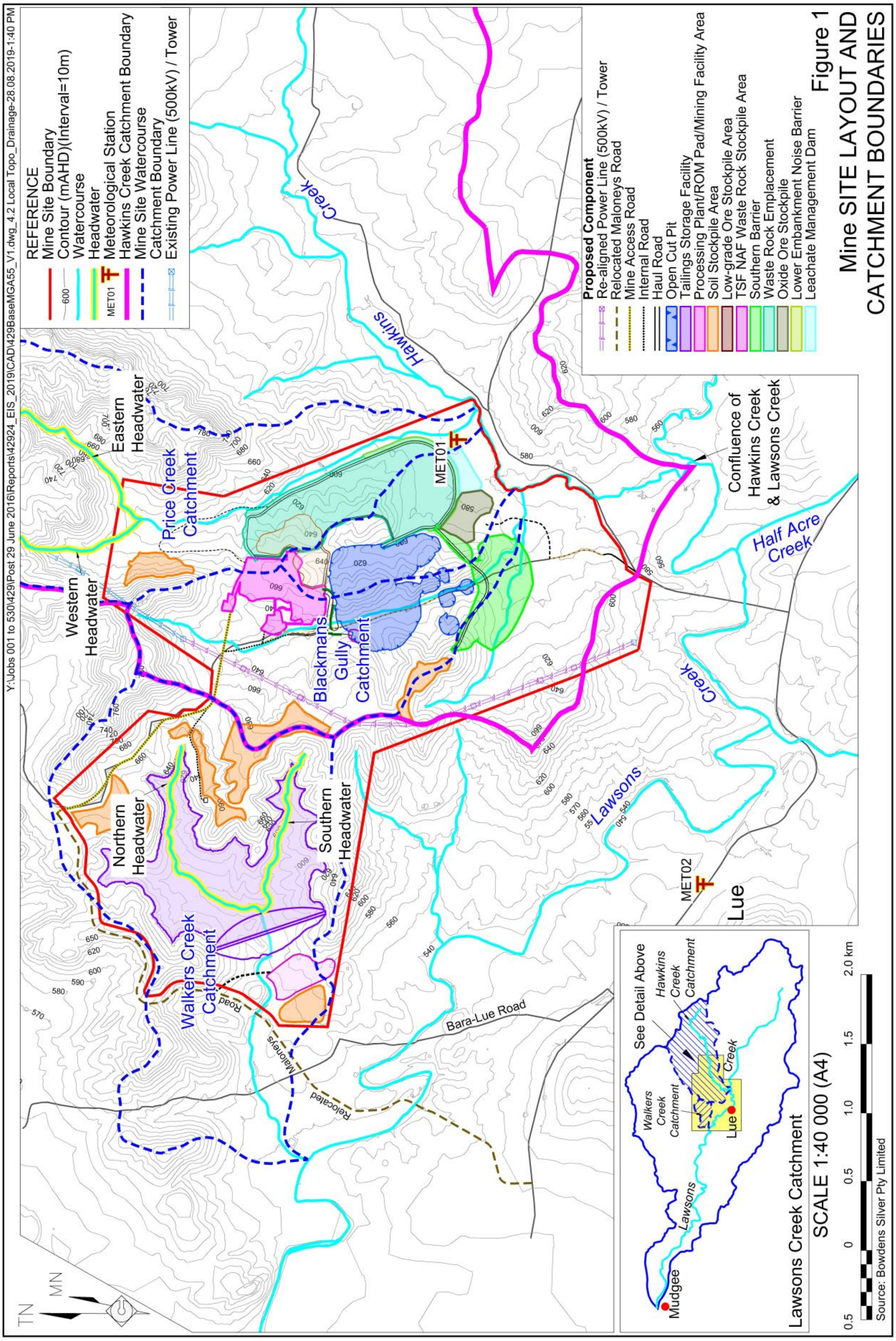
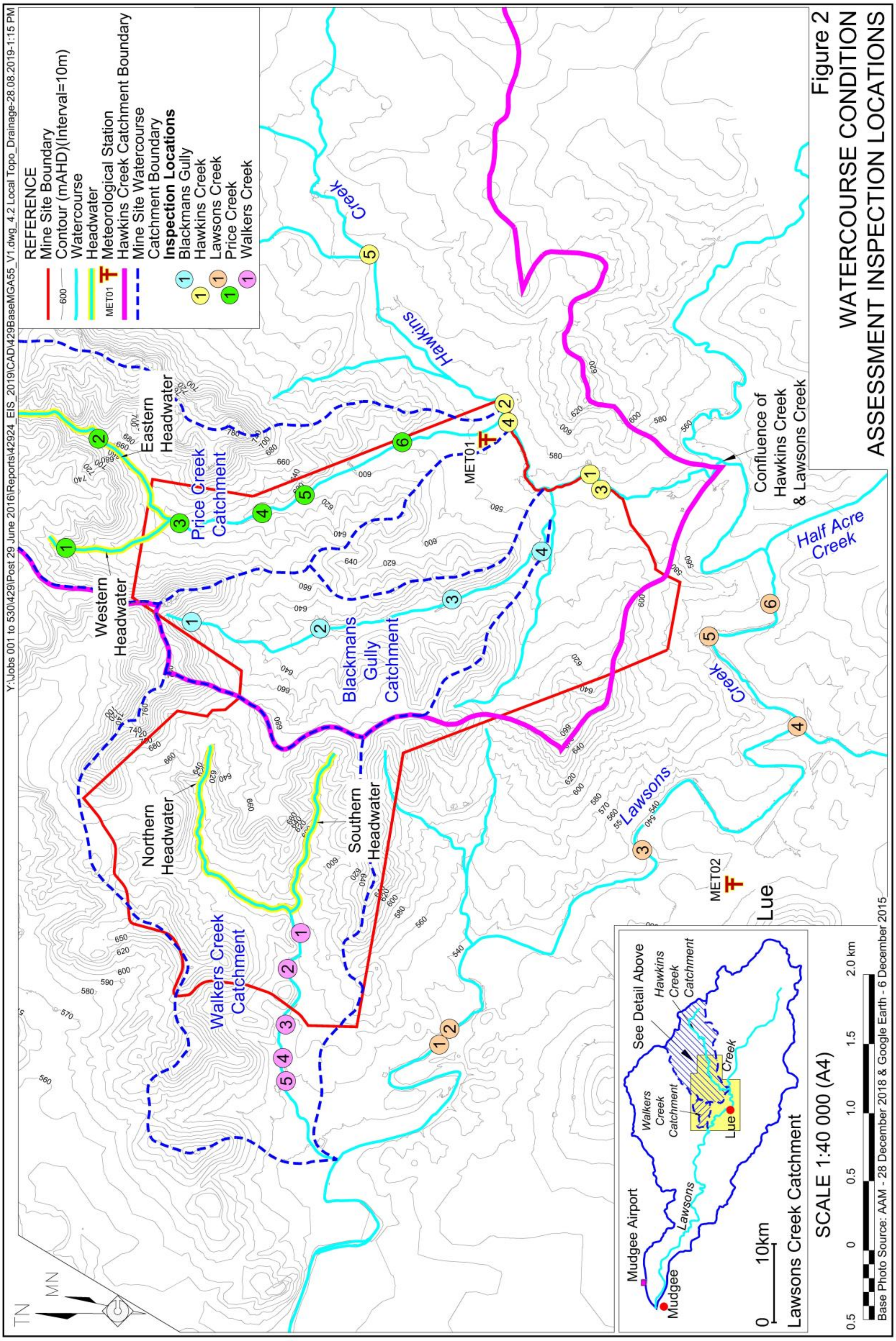


Figure 2 Watercourse Condition Assessment Inspection Locations



Photographs were also taken to assist with this assessment (see **Figure 3**). This geomorphic characterisation was used as a means of quantifying the prevailing hydrologic regime (discharge environment) of the contributing catchment and note any historic changes over time.

The prevailing hydrologic regime is typically influenced principally by a combination of factors such as:

- catchment topography which influences the timing of peak discharge events, flow velocity and watercourse planform;
- catchment geology which influences the nature and type of sediment transported by a watercourse and water chemistry;
- catchment land use and vegetation cover which influences the nature and timing of discharge, sediment loads and water chemistry; and
- climate influences the type of climatic environment which influences the weathering regime of the host geology and consequently the sediment type whilst the frequency and duration of rainfall events influences peak discharge in a given watercourse that subsequently influences its geomorphology.

The interactions of the factors described above effectively place direct controls on the distribution of flow energy within a given watercourse that, as a consequence, influences the erosional and depositional environment within the watercourse itself. Subsequently, the erosional and/or depositional environment influences the physical features (geomorphic units) of the watercourse which may then be used to characterise the nature of the prevailing hydrologic regime of the contributing catchment.

The geomorphic units observed and other geomorphic features such as channel planform and the position of the channel within the valley were then used to place each watercourse into a valley setting to geomorphologically characterise the watercourse in a manner that is in general agreement with the “River Styles” methodology (Brierley et al, 2002).

The physical condition of the subject watercourse at a given location was also assessed in order to place current and historic land uses in context with the current and past hydrologic regime that are expressed as the geomorphologic features described above.

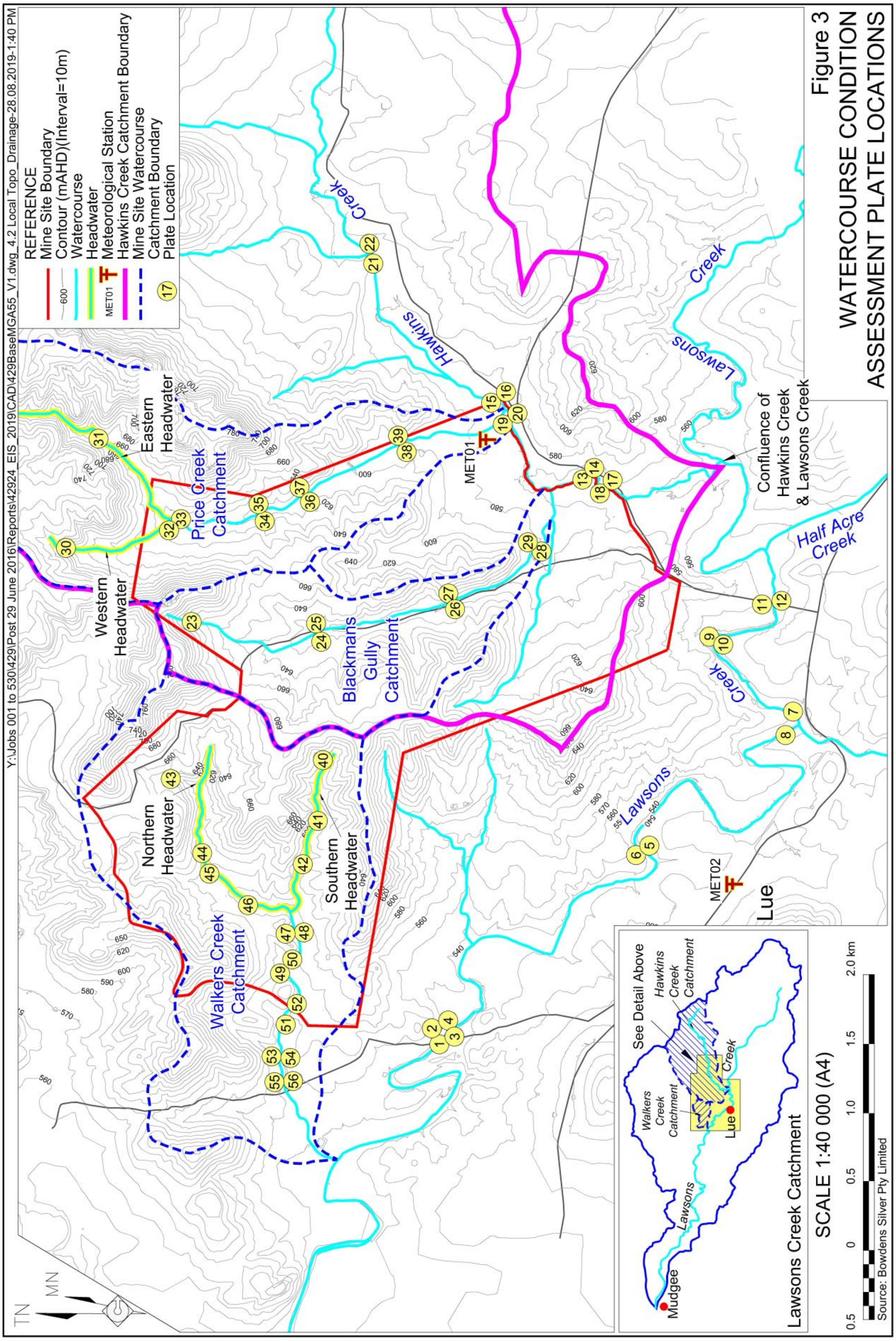
Physical condition was also generally assessed through the observation of evidence of degradation, typically as a result of factors such as:

- animal disturbance (burrows, stock paths);
- loss of riparian vegetation; and
- increased discharge or velocity.

1.3 SUBJECT WATERCOURSES

The subject watercourses inspected were the regional (Lawsons Creek), sub-regional (Hawkins Creek) and Mine Site (Blackmans Gully, Price Creek and Walkers Creek).

Figure 3 Watercourse Condition Assessment Plate Locations



Whilst not directly impacted by the Bowdens Silver Project, the sub-regional Hawkins Creek was inspected at locations upstream and downstream of the Mine Site as Blackmans Gully and Price Creek presently discharge into this system. Similarly, the regional watercourse, Lawsons Creek was inspected downstream of the its confluence with Hawkins Creek so as to characterise the receiving system downstream of the Mine Site. Walkers Creek discharges into Lawsons Creek approximately 4km west of the Mine Site.

Whilst a number of watercourses occur within the Mine Site boundary, the inspection was conducted on those watercourses (and catchments) within which the principal components of the Bowdens Silver Project (see **Figure 1**) would be situated, namely:

i) an open cut pit situated largely within the Blackmans Gully catchment;

ii) a processing plant and related infrastructure situated within the upper reaches of the Blackmans Gully catchment;

iii) low grade ore and non-acid forming construction material stockpiles within the Blackmans Gully, Price Creek and Walkers Creek catchments;

iv) waste rock emplacement (WRE) within the Price Creek catchment (i.e. WRE); and

v) a tailings storage facility (TSF) within the Walkers Creek catchment.

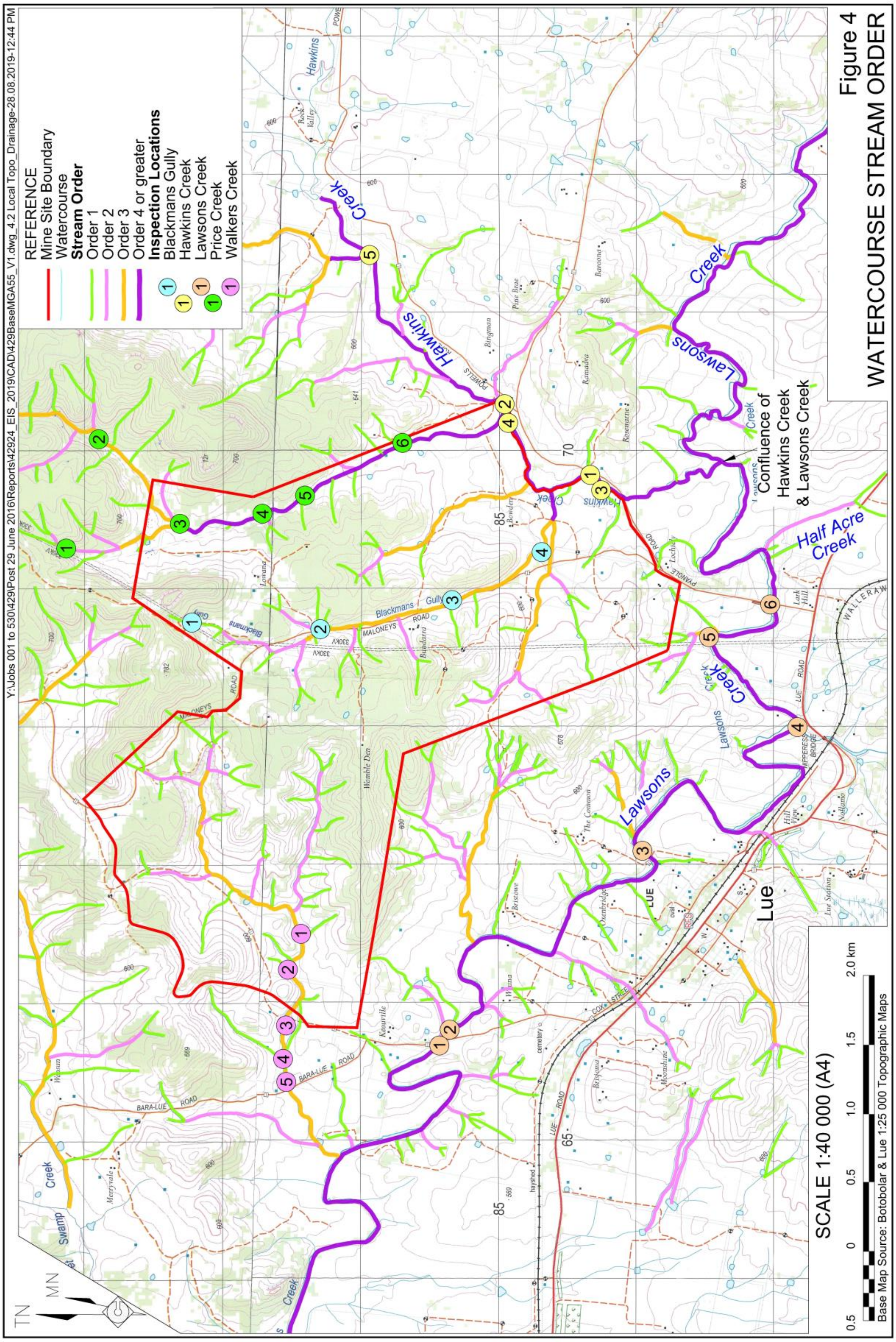
1.4 STREAM ORDER

In accordance with Schedule 2 of the *NSW Water Management (General) Regulation 2018* the stream order classifications for the subject watercourses was undertaken using the Strahler system (Strahler, 1952), utilising the NSW hydroline spatial data that is based on topographic mapping (Lue 1:25 000 and Botobolar 1:25 000) (refer **Figure 4**).

Review of the available spatial data for the Blackmans Gully and Walkers Creek catchments, identified each of these systems as being a 3rd order stream under the Strahler system. However, upon undertaking the physical inspection of the watercourses, it was identified that many of the lower order (i.e. 1st or 2nd) intermittent watercourses, identified on the topographic mapping, were either absent or lacking some or all of those features that would normally be used to characterise a watercourse or stream that would generate physical evidence of its presence (Taylor and Stokes, 2005), such as having a:

- definable bed;
- definable banks;
- surface flow present or evidence of prolonged wetness within the drainage feature;
- fluvial bedforms (e.g. pools, riffles, zones of sediment accumulation etc);
- visible habitats that may sustain aquatic fauna; and
- presence of aquatic flora that would require periods of uninterrupted moisture.

Figure 4 Watercourse Stream Order



Whilst some of the features listed above were observed in some of the lower order watercourses identified from the mapping, not all were present. This would suggest that these "watercourses" are in fact preferential flow paths that only briefly experience discharge during and after a rainfall event. Therefore, these watercourses are better considered as being "ephemeral" (not intermittent or perennial), and as such may be excluded from the stream ordering process in accordance with Strahler (1964), which states:

"Assuming that one has available a channel-network map including all intermittent and permanent flow lines located in clearly defined valleys, the smallest fingertip tributaries are designated order 1".

Subsequently, whilst this report assigns lower order drainage features in the Blackmans Gully and Walker Creek catchments with a stream order in accordance with the available spatial data, based on the physical inspection of these watercourses documented in this report, the ephemeral nature of many lower order drainage features indicate that, rather than being 3rd order watercourses, in actuality Blackmans Gully is instead a 1st order watercourse and Walkers Creek a 2nd order watercourse. This would suggest that the watercourses shown on the hydroline spatial dataset, that is drawn from the Lue 1:25 000 and Botobolar 1:25 000 mapping, have never been "ground-truthed" or subjected to site investigation to verify the accuracy of the original mapped interpretation.

1.5 METEOROLOGY

1.5.1 Climate Data

The closest Bureau of Meteorology (BoM) weather station that provides long term climatic information suitable for use in describing the local climate is located at Mudgee Airport AWS (Station No. 062101), 26km west-northwest of the Mine Site.

Additional climate information was sourced from the two Bowdens weather stations, Lue Met 01 in the eastern section of the Mine Site and Lue Met 02 in Lue, between March 2013 and November 2018 to provide Site-based weather data and conditions. **Figure 2** shows the locations of both Met stations and Mudgee Airport.

Table 1 provides the historical climate data from the BoM, Met 01 and Met 02.

1.5.2 Temperature and Humidity

Temperature and humidity data were sourced from the Mudgee Airport BoM station and show that January is the warmest month with a mean maximum temperature of 31.0°C and mean minimum temperature of 16.1°C. July is the coldest month with a mean maximum temperature of 14.4°C and a mean minimum temperature of 1.1°C.

The lowest average relative humidity generally occurs in the summer months, with January and December sharing the lowest relatively humidity values throughout the year. The highest average relative humidity occurs in June.

Table 1
Historic Climatic Data (Measured)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C) Mudgee Airport Station (Station # 062101) Period of Record 27 Years													
Mean maximum temperature	**31.0**	29.5	26.8	23.0	18.6	15.0	14.4	16.3	19.6	23.1	26.4	28.8	22.7
Mean minimum temperature	16.1	15.6	12.8	8.0	4.0	2.4	**1.1**	1.5	4.3	7.7	11.3	13.8	8.2
Relative Humidity (%) Mudgee Airport Station (Station # 062101) Period of Record 19 Years													
Mean 9:00am relative humidity	63	70	72	71	80	87	87	78	70	61	63	62	72
Mean 3:00pm relative humidity	37	42	42	41	49	57	55	47	44	41	40	37	44
Rainfall (mm) Mudgee Airport Station (Station # 062101) Period of Record 24 Years													
Mean monthly rainfall	67.6	63.1	58.9	33.2	37.9	45.0	43.4	35.2	54.6	51.1	75.4	**80.7**	663.2
Highest monthly rainfall	195.6	233.0	187.0	108.4	124.0	127.2	143.8	112.2	197.4	135.8	162.8	**241.6**	1152.4
Lowest monthly rainfall	10.0	2.2	**0.0**	**0.0**	0.4	1.4	2.6	1.0	0.8	0.2	9.4	15.0	349.6
Highest daily rainfall	65.0	**174.2**	72.0	46.2	44.4	37.0	51.2	51.2	61.0	51.0	57.2	100.8	-
Average Rain Days (>1mm)	7.3	6.9	6.9	4.8	6.3	10.1	9.9	7.6	7.4	8.0	9.3	8.6	93.1
Rainfall (mm) Lue Met01 - Period of Record 5 Years													
Mean monthly rainfall	41.2	57.2	**65.2**	38.6	36.4	58.2	36.6	29.1	53.4	39.6	53.0	61.5	635.3
Highest daily rainfall	45.2	**81**	50.6	31.4	26.8	29.2	41.6	19	50	24.6	49.2	51.6	-
Rainfall (mm) Lue Met02 - Period of Record 5 Years													
Mean monthly rainfall	34.3	56.2	58.0	31.6	31.1	59.2	44.4	32.4	57.8	45.0	56.6	**71.5**	632.2
Highest daily rainfall	41.8	**125.6**	52	32.4	25.8	29.8	41.2	20.8	60.8	30.6	56	58.2	-
Rainfall (mm) SILO Climate Data - Period of Record 129 Years													
Mean monthly rainfall	71.2	63.1	54.2	44.7	44.2	52.9	51.9	50.8	51.9	57.1	64.3	64.7	672.1

1.5.2.1 Rainfall

Rainfall data were sourced from Mudgee Airport BoM, the two on-site Met Stations (**Table 1**) and the Scientific Information for Land Owners (SILO) Climate Database (**Table 2**) which provides data of historical climate records by accessing grids of data (grid reference -32.60, 149.85) that were interpolated from point observations by the Bureau of Meteorology. Whilst the on-site Met Stations have a limited dataset (2013-2018), the rainfall generally reflects rainfall trends displayed in the SILO dataset, albeit at slightly lesser amounts. Average annual rainfall at Mudgee Airport BoM is 663.2mm. The average annual rainfall generated for the two on-site stations is considered less reliable due to the short timeframe covered in the dataset.

Rainfall can be variable, with infrequent, high intensity rainfall events occurring. This is evidenced by the highest daily rainfall values shown in **Table 1** and the fact that the maximum daily rainfall values can be as high as 2 times the average monthly rainfall values (e.g. 125.6mm, Met 02, 25 February 2018). An example of this rainfall variability is the high intensity rainfall event recorded at Met 01 (81mm) and Met 02 (125.6mm) on 25 February 2018 whilst no rainfall was recorded at Mudgee Airport on the same date.

Climatic conditions during the inspection period were mild and clear with the total rainfall recorded at the two Bowdens Silver meteorological stations (Met 01 and Met 02) in the period preceding the inspection as follows.

- Met 01: 3-day rainfall 1.4mm; 7-day rainfall 1.4mm.
- Met 02: 3-day rainfall 2.2mm; 7-day rainfall 2.4mm.

1.5.2.2 Evaporation

Evaporation data have been sourced from SILO with the averages being calculated using Class A Evaporation (post 1970) and synthetic pan evaporation (pre 1970).

Mean monthly evaporation for the Mine Site varies throughout the year, from approximately 222 mm in January and December to 42 mm in June, typically following the seasons throughout the year (**Table 2**). The annual SILO evaporation rate of 1 517 mm exceeds the average annual rainfall averaged calculated from SILO data by a factor of approximately 2.3.

Table 2
Historic Evaporation Data (SILO)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Class A Evaporation (mm) SILO Climate Data - Period of Record 129 Years (pre 1970: synthetic pan evaporation)													
Mean monthly evaporation	222.4	176.7	155.3	101.5	62.6	42.2	46.9	69.7	99.3	142.9	178.0	220.3	1517.0
Mean daily evaporation	7.2	6.3	5.0	3.4	2.0	1.4	1.5	2.2	3.3	4.6	5.9	7.1	-

1.6 LAWSONS CREEK

1.6.1 Catchment Description

Catchment area: 507km^2

Stream order: 4th (in the vicinity of the Mine Site)

AMTD: 64.3km

Elevation: **Headwaters** 910m AHD; **Outlet** 560m AHD

Average grade: 0.54%

Land-use: Cleared agricultural land (pastoral) on lowlands with forested (native vegetation) on uplands.

Lawsons Creek is an unregulated watercourse that drains the regional catchment in which the Mine Site is situated.

The headwaters of the Lawsons Creek system are situated on Mount Graham (elevation approximately 910m AHD) which is approximately 20km east of the Mine Site. The northern and eastern extents of the Lawsons Creek catchment are heavily vegetated and underlain by Permian sediments of the Sydney Basin. The southwestern extent of this catchment is also heavily vegetated but underlain by metasediments and volcanics associated with the Lachlan Orogen.

A review of aerial photography indicates that the bulk of the Lawsons Creek catchment has been altered (cleared) to support agricultural activities. The aerial photography also suggests that, historically, Lawsons Creek was likely to have been an intermittent to perennially discharging watercourse however, subsequent land use changes and the construction of water capture and storage structures to support agriculture have altered the hydrologic regime such that Lawsons Creek may now be described as an intermittent to ephemeral watercourse.

Lawsons Creek in the vicinity of the Mine Site and a subordinate watercourse Half Acre Creek, were inspected on 17 July 2017 at locations from the Bara-Lue Road crossing, approximately 3km west (downstream) of the Mine Site (Adopted Middle Thread Distance (AMTD) 37.8km) and the Pyangle Road crossing, approximately 2.5km south (downstream) of the Mine Site (AMTD 45.2km) which is 1.1km west of the Hawkins and Lawsons Creeks confluence. Property access limited the watercourse inspection at a number of locations along this reach of the watercourse.

1.6.2 Watercourse Inspection Summary

The watercourse inspection identified that Lawsons Creek has historically experienced a discharge regime which triggered channel mobility, as evidenced by the observed presence of reworked alluvial sediments in exposed banks. As a consequence, of this historic discharge environment, the section of Lawsons Creek in the vicinity of the Mine Site displays relatively high channel sinuosity. However, the frequency and magnitude of discharge events has diminished over time as a consequence of reduced runoff volumes due to the capture and storage of overland flow and subordinate watercourse discharge in farm dams.

The channel in the section inspected abuts the valley margin between approximately 10% and 50% of its length and contains a number of pool and riffle sequences with meander curves invariably controlled by rock outcrop. Subsequently, Lawsons Creek in the section inspected may be described as being a meandering, planform controlled discontinuous floodplain watercourse in a partly confined valley setting.

1.6.3 Catchment Inspection Results: Lawsons Creek

Location: Lawsons Creek 1	**Date: 17 July 2017**
Easting: 765696 Northing: 6385447	**AMTD: 37.8km**
Flow condition: Low flow	**Time: 10:00am**
	
Plate 1: Lawsons Creek: View downstream. Note flood debris on fence	**Plate 2: Lawsons Creek: View upstream. Note causeway (culverts out of view to right)**

Channel Geometry:

- **High flow:** Approximately 25m wide; Left bank 5m high, 1:1.5; Right bank 2m high, 1:2 (V:H)
- **Low flow:** Approximately 10m wide, Left bank 1m high, 1:1; Right bank 1m high, 1:1 (V:H)

Planform Geometry: Straight reach, confined section of single channel displaying low to moderate sinuosity.

Geomorphic Units

- **Channel:** Low flow channel: Approximately 1.5m deep pool downstream of riffle. Stable with little evidence of recent mobility
- **Floodplain:** Developed on right bank with evidence of past engagement; poorly developed on left bank due to confined flow.

Bed Condition: Stable, minor evidence of bed aggradation. Algae present.

Bank Condition: Minor erosion on vegetated (trees, grass) right bank, historic slumping on vegetated (grass) left bank.

Sediment

- **Channel:** Gravel / cobbles with interstitial coarse sand and silts. No imbrication evident.
- **Floodplain:** Overbank deposits of silts and clays

Comment: Hydraulic control (Bara-Lue Road crossing) upstream that appears to attenuate moderate to low flow conditions. Some evidence of cobbles and boulders in bank profile suggesting historic channel mobility that is no longer occurring.

Location: Lawsons Creek 2	**Date: 17 July 2017**
Easting: 765796 Northing: 6385359	**AMTD: 38.0km**
Flow condition: Low flow, standing water	**Time: 10:20am**
	
Plate 3: Lawsons Creek: View downstream. Note causeway downstream	**Plate 4: Lawsons Creek: View upstream. Note pooling due to flow attenuation downstream**

Channel Geometry:

- **High flow:** Approximately 20m wide; Left bank (extension of low flow) 4m high, 1:1.5 (V:H); Right bank 2m high, 1:1.5 (V:H)
- **Low flow:** Approximately 10m wide, Left bank as above; Right bank 2m high, 1:1 (V:H)

Planform Geometry: Straight reach, confined section of single channel displaying low to moderate sinuosity.

Geomorphic Units

- **Channel:** Low flow channel: Approximately 2m deep pool upstream of hydraulic control.
- **Floodplain:** Developed on both banks with limited evidence of recent engagement.

Bed Condition: Not visible at time of inspection

Bank Condition: Minor slumping evident (vegetated blocks) on vegetated (trees, grass) right bank, historic undercutting on vegetated (grass) left bank.

Sediment

- **Channel:** Not visible at time of inspection
- **Floodplain:** Overbank deposits of silts and clays

Comment: High capacity low flow channel with hydraulic control (Bara-Lue Road crossing) downstream which appears to attenuate moderate to low flow conditions and artificially influence the water level. Head cut erosion adjacent to right bank due to animal activities (wombat burrows). No evidence of recent channel mobility observed.

Location: Lawsons Creek 3	**Date: 18 July 2017**
Easting: 767095 Northing: 6383969	**AMTD: 40.7km**
Flow condition: Low flow	**Time: 9:30am**

Plate 5: Lawsons Creek: View downstream.

Note flood debris in tree

Plate 6: Lawsons Creek: View upstream.

Note bedrock controls influencing low flow channel

Channel Geometry:

- **High flow:** Approximately 20m wide; Left bank (extension of low flow) 2m high, 1:1.5 (V:H); Right bank 6m high, 1:2 (V:H)
- **Low flow:** Approximately 4m wide, Left bank as above; Right bank 1m high, 1:1 (V:H)

Planform Geometry: Straight reach downstream of bedrock / topography-controlled curve.

Geomorphic Units

- **Channel:** Low flow channel: Broad, 4m wide low flow channel deep pool (thalweg) at outer bank downstream of Half Acre Creek confluence. High flow channel displays minor floodplain development, vegetated depositional bar (cobbles and boulders) and minor channel development on inner bank.
- **Floodplain:** Developed on both banks with limited evidence of recent engagement.

Bed Condition: Stable, algae observed in low flow channel bed, high flow channel well vegetated (grass and tress)

Bank Condition: High flow channel left hand bank bare, evidence of historic slumping or stock impacts. Right bank well vegetated (grass) and stable.

Sediment

- **Channel:** Low flow: silts and clay. High flow: sand, gravel, cobbles and boulders.
- **Floodplain:** Overbank deposits of silts and clays

Comment: High capacity channel receiving Half Acre Creek discharge. Outer bank of meander curve (Lawsons Creek) displays evidence of historic mobility and terracing whilst inner bank (Lawsons Creek) also displays evidence of historic mobility as a result of Half Acre Creek discharge. No current evidence of recent channel mobility was apparent. Flood debris was observed in trees located in high flow channel but not at the level of the high flow channel bank.

Location: Lawsons Creek 4	**Date: 17 July 2017**
Easting: 768002 Northing: 6382846	**AMTD: 43.6km**
Flow condition: Low flow, standing water	**Time: 11:10am**
	
Plate 7: Lawsons Creek: View downstream. **Note flood debris in trees, low flow channel at outer bank**	**Plate 8: Lawsons Creek: View upstream.** **Note pooling at confluence with Half Acre Creek (out of view, lower right)**

Channel Geometry:

- **High flow:** Approximately 50m wide; Left bank (extension of low flow) 5m high, 1:1 (V:H); Right bank 2m high, 1:2 (V:H)
- **Low flow:** Approximately 2m wide, Left bank as above; Right bank 2m high, 1:3 (V:H)

Planform Geometry: Meander curve.

Geomorphic Units

- **Channel:** Low flow channel: Approximately 2m deep pool (thalweg) at outer bank downstream of Half Acre Creek confluence. High flow channel displays minor floodplain development, vegetated depositional bar (cobbles and boulders) and minor channel development on inner bank.
- **Floodplain:** Developed on both banks with limited evidence of recent engagement.

Bed Condition: Stable, algae observed in low flow channel bed, high flow channel well vegetated (grass and tress)

Bank Condition: High flow channel left hand bank bare, evidence of historic slumping or stock impacts. Right bank well vegetated (grass) and stable.

Sediment

- **Channel:** Low flow: silts and clay. High flow: sand, gravel, cobbles and boulders.
- **Floodplain:** Overbank deposits of silts and clays

Comment: High capacity channel receiving Half Acre Creek discharge. Outer bank of meander curve (Lawsons Creek) displays evidence of historic mobility and terracing whilst inner bank (Lawsons Creek) also displays evidence of historic mobility as a result of Half Acre Creek discharge. No current evidence of recent channel mobility was apparent. Flood debris was observed in trees located in high flow channel but not at the level of the high flow channel bank (i.e. bankfull discharge not achieved).

Location: Lawsons Creek 5	**Date: 17 July 2017**
Easting: 768637 Northing: 6383461	**AMTD: 44.5km**
Flow condition: Low flow, standing water	**Time: 12:10pm**
	
Plate 9: Lawsons Creek: View downstream. **Note evidence of past lateral channel mobility now inactive and vegetated (right of frame).**	**Plate 10: Lawsons Creek: View upstream.** **Note stock paths and vertical banks.**

Channel Geometry:

- **High flow:** Approximately 20m wide; Left bank 2m high, 1:4 (V:H); Right bank 4m high, 1:2 (V:H)
- **Low flow:** Approximately 2m wide, Left bank 0.5m high 1:3 (V:H); Right bank 0.5m high 1:3 (V:H).

Planform Geometry: Curved reach (meander?) downstream of hydraulic control (road crossing).

Geomorphic Units

- **Channel:** Low flow channel: Evidence of historic point bar deposition on inner bank of meander curve. Vegetated high flow channel displays minor floodplain development.
- **Floodplain:** Developed on both banks with limited evidence of recent engagement.

Bed Condition: Stable and vegetated (grass, some woody shrubs)

Bank Condition: Left and right bank well vegetated (grass) and stable, evidence of historic cut and slumping that appears in situ and vegetated.

Sediment

- **Channel:** Silts and clay, minor boulders.
- **Floodplain:** Overbank deposits of silts and clays

Comment: High capacity channel displaying capacity to convey discharge within banks. Evidence of historic lateral mobility apparent. Engagement of floodplain likely on inner bank, however no recent evidence of bankfull discharge apparent. Presence of grass in channel bed, floodplain and bank sections indicate lower magnitude and frequency of discharge in the system (bed aggradation).

Location: Lawsons Creek 6	**Date: 17 July 2017**
Easting: 768886 Northing: 6383017	**AMTD: 45.2km**
Flow condition: Low flow, standing water	**Time: 12:00pm**

Plate 11: Lawsons Creek: View downstream.
Note reed establishment in channel

Plate 12: Lawsons Creek: View upstream.
Note water level below culvert invert

Channel Geometry: Single channel with pooling potentially concealed low flow channel, 20m wide, right bank 2m 1:3 (V:H), left bank 2m 1:2 (V:H).

Planform Geometry: Straight reach downstream of hydraulic control (road crossing)

Geomorphic Units

- **Channel:** Single channel: Pooling and significantly vegetated (reeds) both downstream and upstream of hydraulic control
- **Floodplain:** Developed on both banks with limited evidence of recent engagement.

Bed Condition: Not observed however considered to be stable as a consequence of the hydraulic control and evidenced by the presence of reed beds.

Bank Condition: Left and right bank well vegetated (grass) and stable, with the exception of a section on the left bank that has been treated with rock to prevent piping from road runoff.

Sediment

- **Channel:** Not visible at time of inspection
- **Floodplain:** Overbank deposits of silts and clays with some gravel and coarse sand.

Comment: High capacity channel with hydraulic control (Pyangle Road crossing) downstream which appears to attenuate flow conditions, artificially influence the water levels present and potentially lead to bed aggradation.

1.7 HAWKINS CREEK

1.7.1 Catchment Description

Catchment area: 61km^2

Stream order: 4th

AMTD: 17.1km

Elevation: **Headwaters** 910m AHD; **Outlet** 560m AHD

Average grade: 2%

Land-use: Cleared agricultural land (pastoral) on lowlands with forested (native vegetation) on uplands.

Hawkins Creek is an unregulated watercourse that drains the sub-regional catchment in which the Mine Site is situated. The headwaters of the Hawkins Creek system are located in the Upper Growee area at an elevation of approximately 920m AHD, approximately 11km east of the Mine Site. Similar to the Lawsons Creek catchment, the northern and eastern extents of the Hawkins Creek catchment are heavily vegetated and underlain by Permian sediments of the Sydney Basin, however, the southern extents of the catchment display less relief and are generally cleared pasture.

A review of aerial photography indicates that the approximately half of the Hawkins Creek catchment has been altered (cleared) to support agricultural activities. The aerial photography also indicates that Hawkins Creek historically displayed some channel mobility however this mobility is no longer apparent. However, similar to Lawsons Creek, land use change and the construction of water capture and storage structures to support agriculture have altered the hydrologic regime such that Hawkins Creek.

Hawkins Creek was inspected on 17 and 18 July 2017 at locations commencing adjacent to Battens (Powells) Road, approximately 0.8km south of the Mine Site (AMTD 1.1km) and traversing upstream, approximately 2.5km east (upstream) of the Mine Site (AMTD 4.1km). Property access limited the watercourse inspection along the full extent of the watercourse.

1.7.2 Watercourse Inspection Summary

Similar to Lawsons Creek, the watercourse inspection identified that Hawkins Creek would have historically experienced higher discharge regime which has diminished over time as a consequence of reduced runoff volumes due to the capture and storage of overland flow and subordinate watercourse discharge in farm dams.

The channel displays evidence of bed aggradation and the subsequent establishment of reedy vegetation has led to a discontinuous low flow channel within an historic high flow channel. This would imply that historically, with a continuous channel, Hawkins Creek could have been characterised as a low/moderate sinuosity, sand bed watercourse in an alluvial valley setting however, subsequent bed aggradation has led to channel discontinuity suggesting that Hawkins Creek is transitioning into an intact valley fill chain of ponds watercourse.

1.7.3 Catchment Inspection Results

Location: Hawkins Creek 1	**Date: 17 July 2017**
Easting: 769822 Northing: 6384347	**AMTD: 1.3km**
Flow condition: Low flow, standing water	**Time: 12:35pm**
	
Plate 13: Hawkins Creek: View downstream. **Note vegetation obscuring channel and bedrock on right bank.**	**Plate 14: Hawkins Creek: View upstream.** **Note pool with no apparent low flow channel acting as an outlet.**
Channel Geometry: Discontinuous, poorly defined low and high flow channels. 8m wide, Left bank 2m 1:3 (V:H), Right bank 2m 1:2 (V:H).	
Planform Geometry: Straight reach with some minor meanders	
Geomorphic Units • **Channel:** Single, flat broad channel: Discontinuous with pooling and significantly vegetated (reeds) • **Floodplain:** In the absence of a high flow channel, assumed to be extensively developed as valley fill and overbank deposits.	
Bed Condition: Not observed however considered to be stable as a consequence of the vegetation and pooling.	
Bank Condition: Left and right bank well vegetated (reeds and grass) and stable. Some bedrock controls	
Sediment • **Channel:** Fine, organic rich (observed in section separating pools) • **Floodplain:** Overbank deposits consisted of fine material.	
Comment: Poorly developed low and high flow channel with no recent evidence that discharge exceeded channel capacity although this is assumed to have historically occurred during frequent rainfall events. Discontinuous low flow channel likely due to a reduction in the frequency and magnitude of peak discharge events.	

Location: Hawkins Creek 2	**Date: 17 July 2017**
Easting: Northing	**AMTD:**
Flow condition: Low flow, standing water	**Time: 1:00pm**
	
Plate 15: Hawkins Creek: View north. **Note standing water in low capacity, low flow channel and absence of high flow bank.**	**Plate 16: Hawkins Creek: View upstream.** **Note pool with rock control on right bank.**

Channel Geometry: Discontinuous single low flow channel with pool and no evidence of high flow channel. 2m wide, Left bank 0.5m 1:1 (V:H), Right bank 0.5m 1:1 (V:H).

Planform Geometry: Straight reach with pools and meanders (likely rock controlled)

Geomorphic Units

- **Pool:** 25m length, 8m wide, Left bank 1m 1:3, Right bank 1m 1:1 (V:H)
- **Channel:** Single, flat, broad, discontinuous low flow channel with vegetated bed and banks. Channel is low capacity and readily engages with floodplain.
- **Floodplain:** In the absence of a high flow channel, assumed to be extensively developed as valley fill and overbank deposits.

Bed Condition: Stable, vegetated (grass).

Bank Condition:

- **Pool:** Stable, vegetated. Left bank (long grass), Right bank (grass) with some rock control.
- **Channel:** Stable, vegetated (grass).

Sediment

- **Channel:** Fine, silts and sands.
- **Floodplain:** Fine, silts and sands.

Comment: Discontinuous low capacity low flow channel interspersed by pools. Active engagement with floodplain apparent, whilst no terracing evident, apparent valley fill nature of floodplain suggests historic lateral mobility of channel and reworking of sediments.

Location: Hawkins Creek 3	**Date: 18 July 2017**
Easting: 769730 Northing: 6384265	**AMTD: 1.1km**
Flow condition: No flow	**Time: 11:25am**
	
Plate 17: Hawkins Creek: View downstream. **Note bank undercutting, bare banks and sand.**	**Plate 18: Hawkins Creek: View upstream.** **Note heavily vegetated low flow channel (reeds) and vegetated high flow channel (grass).**

Channel Geometry: Continuous low flow channel (assumed by reeds) 3 wide, unable to discern banks due to vegetation. High flow channel. 12m wide, Left bank 2m 3:1 (V:H), Right bank 2m 1:1 (V:H).

Planform Geometry: Meander curve

Geomorphic Units

- **Scour Pool:** Adjacent to outer bank of high flow channel (downstream) in thalweg
- **Channel:** Single, flat, broad, likely continuous low flow channel with heavily vegetated bed and banks (reeds). Channel is low capacity and readily achieves bankfull discharge as evidenced by active erosion in of high flow banks. High flow channel is high capacity with limited engagement of floodplain.
- **Floodplain:** Not laterally extensive due to terrain (limited to valley fill). Evidence of cut-off channel and point bar development on inner bank of meander curve.

Bed Condition: Stable, vegetated (grass and reeds).

Bank Condition: Stable, vegetated (grass). Undercutting and slumping observed on outer bank (right) of high flow channel suggesting lateral mobility. Historic piping of left bank observed at point where cut-off re-enters channel.

Sediment

- **Channel:** Fine, silts with sand and gravel observed in high flow channel bed.
- **Floodplain:** Fine, silts, sands and gravel (observed in bank profile).

Comment: Location where discharge from Blackmans Gully enters Hawkins Creek via overland flow after redirection by contour bank. Some gully erosion apparent in Blackmans Gully flow path. Sediment in this location distinctly coarser and dominated by sand with minor gravel.

Location: Hawkins Creek 4	**Date: 18 July 2017**
Easting: 770204 Northing: 6384925	**AMTD: 2.2km**
Flow condition: Low flow	**Time: 11:45am**
	
Plate 19: Hawkins Creek: View downstream. **Note standing water, rock on banks. Discharge from Price Creek enters Hawkins Creek in centre of frame**	**Plate 20: Hawkins Creek: View upstream.** **Note historically eroded, vegetated high flow bank with evidence of gully erosion (far left).**

Channel Geometry: Continuous low flow channel between pools of varying geometry up to 2m wide, Left bank 3m 1:2, Right bank 1m 1:1 (V:H). High flow channel. 12m wide, Left bank 2m 3:1 (V:H), Right bank 2m 1:1 (V:H).

Planform Geometry: Meanders connected by straight reaches (some rock controls), intersected by pools

Geomorphic Units

- **Channel:** Single, flat, broad, discontinuous low flow channel between pools. Channel is low capacity and readily achieves bankfull discharge as evidenced by active erosion in the high flow banks. High flow channel is high capacity with limited engagement of floodplain.
- **Floodplain:** Not laterally extensive due to terrain (limited to valley fill). Evidence of cut-off channel and point bar development on inner bank of meander curve.

Bed Condition: Stable, vegetated (grass and reeds).

Bank Condition: Stable, vegetated (grass). Undercutting and slumping observed on outer bank (right) of high flow channel suggesting lateral mobility. Historic piping of right bank observed at point where Price Creek discharge enters channel.

Sediment

- **Channel:** Fine, silts with sand and gravel observed in high flow channel bed.
- **Floodplain:** Fine, silts, sands and gravel (observed in bank profile).

Comment: Location where discharge from Price Creek enters Hawkins Creek via overland flow after redirection by contour banks. Some gully erosion apparent in the Price Creek flow path. Sediment in this location distinctly coarser and dominated by sand with minor gravel.

Location: Hawkins Creek 5	**Date: 17 July 2017**
Easting: 771430 Northing: 6385932	**AMTD: 4.1km**
Flow condition: Low flow, standing water	**Time: 1:15pm**
	
Plate 21: Hawkins Creek: View downstream. Note standing water in pool, steep outer bank with animal disturbance and coarse material in profile.	**Plate 22: Hawkins Creek: View upstream. Note pool and low flow channel, steep sided banks and evidence of bed and bank degradation from stock access.**

Channel Geometry: Continuous low flow channel, 0.5m wide, 0.2m 1:1 (V:H) banks and high flow channel. 3m wide, Left bank 1.5m 1:1 (V:H), Right bank 1.5m 1:1 (V:H).

Planform Geometry: Straight reach with small pool upstream and large scour pool downstream. Evidence of lateral mobility (undercutting) and scour in both bed and banks.

Geomorphic Units

- Pools:
  - **Upstream:** 3m length, 3m wide, Left bank 1.5m 1:1, Right bank 1.5m 1:1 (V:H)
  - **Downstream:** 6m length, 5m wide, Left bank 2m 1:1, Right bank 1.5m 1:1 (V:H)
- Channel:
  - **Low flow:** Continuous, low capacity channel.
  - **High flow:** Steep sided, moderate capacity channel. Bare banks.
- **Floodplain:** In the absence of a high flow channel, assumed to be extensively developed as valley fill and overbank deposits. Poorer vegetation condition lower than previous sites inspected.

Bed Condition: Unstable, poorly vegetated (short grass and reeds), degraded by stock access with evidence of channel incision and mobility (scour).

Bank Condition:

- **Pools:** Unstable, poorly vegetated (grass) (right bank, downstream pool only). Bare banks with evidence of undercutting, slumping and animal burrows (downstream pool).
- **Channel:** Unstable, poorly vegetated (grass), degraded by stock access.

Sediment

- **Channel:** Fine, silts.
- **Floodplain:** Fine, silts, sands and gravel (observed in bank profile).

Comment: Location is more degraded than previous sites due to stock access and scour. Scour at this location likely due to grade as bed elevation drops approximately 1.5m from 30m upstream to channel invert at pool inlet. Further degradation attributed to animal disturbance and lack of vegetation cover. Inspection of exposed profile in banks indicates valley fill being reworked.

1.8 BLACKMANS GULLY

1.8.1 Catchment Description

Catchment area: 2.3km^2

Stream order: 4th (mapping), 1st (inspection)

AMTD: 3.5km

Elevation: **Headwaters** 750m AHD; **Outlet** 565m AHD

Average grade: 5.3%

Land-use: Minor areas of cleared agricultural land (pastoral) on lowlands with forested (native vegetation) on uplands and slopes.

Blackmans Gully is an unregulated watercourse that drains a catchment in the central section of the Mine Site. The headwaters of the Blackmans Gully system are located at an elevation of approximately 750m AHD, approximately 2.1km north of the proposed open cut pit. The northern, eastern and western extents of the catchment are heavily vegetated and underlain by Triassic and Permian sediments whilst the southern section of the catchment is underlain by Permian volcanics. As a consequence of activities to facilitate agricultural activity, the Blackmans Gully catchment discharges via overland flow that is redirected via a contour bank. This discharge enters Hawkins Creek in the vicinity of Hawkins Creek Location 3 (Section 1.1.6)

The watercourse inspection was conducted on 18 July 2017 along the entire reach of the watercourse.

1.8.2 Watercourse Inspection Summary

In summation, Blackmans Gully transitions from a topographically controlled, low capacity preferential flow path (Blackmans Gully Location 1) to a 1st order watercourse with a moderate capacity channel as the contributing catchment increases and where historic modifications to facilitate drainage along Maloneys Road has occurred (Blackmans Gully Location 2). Downstream of Blackmans Gully Location 2, this stream order is maintained, however the continued increase in contributing catchment has led to a coincident increase in channel capacity.

Subsequently, Blackmans Gully is characterised as a 1st order watercourse in a confined valley setting with occasional floodplain pockets, principally in the lower reaches.

1.8.3 Catchment Inspection Results: Blackmans Gully

Location: Blackmans Gully 1	**Date: 18 July 2017**
Easting: 768767 Northing: 6387234	**AMTD: 3.3km**
Flow condition: No flow	**Time: 10:05am**

Plate 23: Blackmans Gully: View across minor capacity channel at this location. Note vegetation cover and absence of geomorphic units.

Channel Geometry: Relatively indistinct, minor low capacity channel. Consistent geometry approximately 0.2m wide, Left bank 0.5m 1:4 (V:H), Right bank 0.5m 1:4 (V:H).

Planform Geometry: Straight. Topographically controlled

Geomorphic Units

- **Channel:** Single, incised low capacity channel.
- **Floodplain:** None developed.

Bed Condition: Stable, vegetated (grass).

Bank Condition: Stable, vegetated (grass).

Sediment

- **Channel:** Fine, silts with cobbles observed in channel bed.
- **Floodplain:** None developed however fine, silts and sands on adjacent slope.

Comment: Location is a minor drainage feature in the headwaters of Blackmans Gully catchment. The watercourse in this location does not display evidence of the development of geomorphic units such as a low flow and high flow channel. The watercourse in this location appears to be a preferential flow path from the local topography concentrating and directing runoff.

Location: Blackmans Gully 2	**Date: 18 July 2017**
Easting: 768697 Northing: 6386302	**AMTD: 2.3km**
Flow condition: No flow	**Time: 10:20am**
	
Plate 24: Blackmans Gully: View looking upstream. **Note farm dam embankment right of frame.**	**Plate 25: Blackmans Gully: View across top of right bank to top of left bank.** **Note Maloneys Road adjacent to top of left bank and placement of material in right (centre) of frame.**

Channel Geometry: Continuous low flow channel. Vertical banks approximately 1m high, flat channel bed approximately 1m wide.

Planform Geometry: Straight, follows Maloneys Road alignment.

Geomorphic Units

- **Channel:** Single, flat, broad, low flow channel. Channel is of moderate capacity and has likely been altered to facilitate drainage of Maloneys Road.
- **Floodplain:** Not laterally extensive due to topography and Maloneys Road.

Bed Condition: Stable, vegetated.

Bank Condition: Stable, vegetated (grass). Historic placement of material from grading of Maloneys Road apparent.

Sediment

- **Channel:** Sand, gravel and minor cobbles observed in channel.
- **Floodplain:** Sand, gravel and minor cobbles.

Comment: Location where, similar to the Blackmans Gully Location 1, the watercourse has not developed geomorphic features due to a limited contributing catchment. Two farm dams have been constructed east and west of the watercourse and each of these hydraulic controls intercepts runoff from two sub-catchments, thus reducing discharge volumes in the watercourse at this location. In addition, it is likely that excavation and watercourse re-alignment has historically been undertaken to facilitate road drainage in this location.

Location: Blackmans Gully 3	**Date: 18 July 2017**
Easting: 768913 Northing: 6385346	**AMTD: 1.3km**
Flow condition: No flow in channel, minor pooling	**Time: 10:30am**
	
Plate 26: Blackmans Gully: View looking upstream. **Note bed cut / drop and pool formed at base. Stock / wildlife track at lower right of frame.**	**Plate 27: Blackmans Gully: View downstream.** **Note vegetated low capacity, low flow channel and absence of high flow channel.**

Channel Geometry: Continuous flat bed, low flow channel. Vertical banks approximately 0.8m high, flat channel bed approximately 1.5m wide.

Planform Geometry: Straight.

Geomorphic Units

- **Channel:** Single, flat, broad, low flow channel.
- **Floodplain:** Not laterally extensive due to topography.

Bed Condition: Stable, vegetated (sedge grass).

Bank Condition: Stable, vegetated (reeds) at top of bank but bare vertical banks. Evidence of stock / wildlife crossing leading to minor degradation of bank.

Sediment

- **Channel:** Fine silt, clay, sand, gravel and minor cobbles observed in channel.
- **Floodplain:** Fine silt, clay, sand, gravel and minor cobbles.

Comment: Location where the watercourse has not developed geomorphic features due to topographic controls. Notable change in type of vegetation and minor pooling of standing water suggests potential minor, periodic, groundwater discharge occurs at this location.

Location: Blackmans Gully 4	**Date: 18 July 2017**
Easting: 769262 Northing: 6384699	**AMTD: 0.5km***
Flow condition: No flow.	**Time: 11:00am**
	
Plate 28: Blackmans Gully: View looking upstream. **Note steep left hand (outer) bank and vegetated right hand (inner) bank.**	**Plate 29: Blackmans Gully: View downstream.** **Note angular, sub-rounded cobbles in bed and bank.**

Channel Geometry: High capacity, continuous flat bed channel of varying width (1m – 2m).

- **Low Flow Channel:** Low flow channel: vertical Right (outer) bank Approx.' 1.5m high, vertical Left (inner) bank Approx.' 0.5m high.
- **High Flow Channel:** Channel development evident with vertical Right (outer) bank (as for low flow channel), 1.5m, 1:3 (V:H) Left (inner) bank, width (top of banks) Approx.' 6m

Planform Geometry: Curve.

Geomorphic Units

- **Channel:** Mobile, single, flat, broad, channel.
- **Floodplain:** Extensive from top of right hand (outer) bank however no evidence of recent engagement.

Bed Condition: Incised, bare low flow, vegetated (grass) high flow.

Bank Condition: Unstable, bare Right (outer) bank with active erosion evidence of channel mobility. Stable Left (inner) bank (grass, reeds and small trees).

Sediment

- **Channel:** Fine silt, clay, sand, grave, cobbles and boulders observed in channel.
- **Floodplain:** Fine silt, clay, sand, gravel and minor cobbles.

Comment: High capacity channel displaying evidence of historic mobility and lateral movement in right hand (outer) bank profile.

***** AMTD from clearly defined channel, pastoral modifications overprint relict channel geometry.

1.9 PRICE CREEK

1.9.1 Catchment Description

Catchment area: 5.2km^2

Stream order: 4th (mapping), 2nd (inspection)

AMTD: 5.8km (including eastern headwater); western headwater 0.99km

Elevation: **Headwaters** 840m Australian Height Datum (AHD) (eastern headwater); **Outlet** 570m AHD

Average grade: 7.7%

Land-use: Minor areas of cleared agricultural land (pastoral) in the lower valley fill sections with forested (native vegetation) on uplands and slopes.

Price Creek is an unregulated watercourse that drains a catchment in the eastern section of the Mine Site. The twin headwaters (eastern and western) of the Price Creek system are respectively situated at elevations of approximately 840m AHD and 740m AHD, approximately 4.8km (eastern headwater) northeast of the proposed open cut pit. The extents of the catchment are heavily vegetated and underlain by Triassic and Permian sediments whilst the cleared southern section of the catchment is underlain by Permian volcanics. The confluence of the eastern and western headwaters is located in the main Price Creek valley at 2.8km AMTD. Similar to Blackmans Gully, the Price Creek catchment discharges via overland flow after interception and redirection by a series of contour banks. Discharge from Price Creek enters Hawkins Creek in the vicinity of Hawkins Creek Location 4.

The watercourse inspection was conducted on 18 July 2017 along the entire reach of the western headwater, a section of the eastern headwater and the entire section of the main Price Creek watercourse.

1.9.2 Watercourse Inspection Summary

The watercourse inspection identified that the eastern and western headwaters are topographically controlled, incised flow paths that merge to form a moderate capacity channel as the contributing catchment increases. Substantial historic modifications such as earthworks, contour banks and shallow drains in the downstream reach of the watercourse to facilitate agricultural activity have effectively removed the watercourse in this area with the former channel overprinted by pasture and only visible from aerial imagery.

Subsequently, Price Creek is characterised as a watercourse in a confined valley setting with occasional floodplain pockets.

1.9.3 Catchment Inspection Results

Location: Price Creek 1 (western headwater)	**Date: 18 July 2017**
Easting: 769284 Northing: 6388144	**AMTD: 0.8km***
Flow condition: No flow	**Time: 12:15pm**

Plate 30: Price Creek: View downstream.

Note steep terrain, vegetation cover, colluvial boulders and felled trees as a result of powerline easement management.

Channel Geometry: Flat bottomed, continuous, low capacity channel. 0.5m, 1: 1 (V:H) banks and 1m wide channel.

Planform Geometry: Straight. Topographically controlled

Geomorphic Units

- **Channel:** Single, incised low capacity channel.
- **Floodplain:** None developed.

Bed Condition: Stable, vegetated (bracken, grass).

Bank Condition: Stable, vegetated (bracken, grass).

Sediment

- **Channel:** Coarse sand and gravel.
- **Floodplain:** Coarse sand and gravel.

Comment: Location is a minor, incised drainage feature in the western headwaters of Price Creek catchment which does not display evidence of the development of geomorphic units such as a low flow and high flow channel. The watercourse in this location is a topographically controlled preferential flow path at the base of a sandstone scarp.

***** AMTD measured from confluence with eastern headwater

Location: Price Creek 2 (eastern headwater)	**Date: 18 July 2017**
Easting: 770088 Northing: 6387900	**AMTD: 0.8km***
Flow condition: No flow	**Time: 12:40pm**

Plate 31: Price Creek: View upstream.

Note vegetated, steeply sloping banks and broad, shallow, low capacity channel devoid of vegetation.

Channel Geometry: Shallow, flat bottomed and continuous 1m wide low capacity channel with 10m, 1:2 (V:H) banks.

Planform Geometry: Straight, topographically controlled (minor outcrop controls).

Geomorphic Units

- **Channel:** Single, incised low capacity channel.
- **Floodplain:** Minor development in downstream sections.

Bed Condition: Unvegetated however appears stable with no evidence of active erosion.

Bank Condition: Stable, vegetated (trees, woody shrubs and grass).

Sediment

- **Channel:** Silts, clays, coarse sand, gravel and boulders.
- **Floodplain:** Where developed, fine silts and clays.

Comment: Incised drainage feature in this location is a second order watercourse in the eastern headwaters of Price Creek catchment. The watercourse in this location is topographically controlled with minor floodplain development evident, particularly in the downstream sections.

* AMTD measured from confluence with western headwater

Location: Price Creek 3	**Date: 18 July 2017**
Easting: 769487 Northing: 6387313	**AMTD: 2.7km**
Flow condition: No flow.	**Time: 12:55pm**
	
Plate 32: Price Creek: View looking to left hand bank. **Note bare bank and outcrop (rock control.**	**Plate 33: Price Creek: View upstream from right hand bank (channel at right).** **Note grassed floodplain with animal burrow.**

Channel Geometry: Broad, continuous, single channel with 2m high, 1:2 (V:H) banks and 1m wide low flow channel at base (0.1m banks with 1:1 (V:H) slope).

Planform Geometry: Straight. Topographically controlled with minor outcrop control.

Geomorphic Units

- **Channel:** Incised, single, flat, broad, channel with minor low flow channel.
- **Floodplain:** Well developed and extensive, no evidence of recent engagement.

Bed Condition: Stable, bare low flow, vegetated (grass and blackberry) high flow.

Bank Condition: Stable, some sections inspected were relatively bare, with the exception of minor grass and small trees (see **Plate 32**). Blackberry vines were also prevalent in sections (see **Plate 33**).

Sediment

- **Channel:** Fine silt and clay.
- **Floodplain:** Fine silt and clay with sand, gravel evident in bank profile.

Comment: High capacity channel receiving discharge from eastern and western headwaters of the catchment. Evidence of relict channel identified upstream however abandonment of this watercourse more attributable to construction of farm dam upstream than evidence of historic mobility. Well-developed floodplain at this location is a consequence of partially confined flow leading to valley filling.

Location: Price Creek 4	**Date: 18 July 2017**
Easting: 769560 Northing: 6386729	**AMTD: 2.0km**
Flow condition: No flow.	**Time: 1:20pm**

Plate 34: Price Creek: View looking upstream.

Note bare right hand bank with outcrop (rock) control, vegetated left hand bank (blackberry vines).

Plate 35: Price Creek: View towards left hand bank.

Note bare bank with erosion.

Channel Geometry: Broad, continuous, single channel with 2m high, 1:2 (V:H) banks and 1m wide low flow channel at base (0.1m banks with 1:1 (V:H) slope).

Planform Geometry: Straight. Topographically controlled with minor outcrop control.

Geomorphic Units

- **Channel:** Incised, single, flat, broad, channel with minor low flow channel.
- **Floodplain:** Developed and apparent, no evidence of recent engagement.

Bed Condition: Stable, bare low flow, vegetated (grass and blackberry) high flow.

Bank Condition: Sections of the bank inspected were relatively bare, with the exception of minor grass and small trees and unstable showing evidence of erosion and animal tracks (see **Plate 35**). Blackberry vines were also prevalent in sections (see **Plate 34**).

Sediment

- **Channel:** Fine silt and clay.
- **Floodplain:** Fine silt and clay with sand, gravel evident in bank profile.

Comment: Incised channel abutting western slope of narrow valley in this section of Price Creek. Valley fill material likely to be a mix of alluvial and colluvial material, as evidenced by large, angular boulders observed in the banks (see **Plate 34**, lower left of frame).

<table>
<tr><td>Location: Price Creek 5</td><td>Date: 18 July 2017</td></tr>
<tr><td>Easting: 769680 Northing: 6386415</td><td>AMTD: 1.7km</td></tr>
<tr><td>Flow condition: No flow.</td><td>Time: 1:35pm</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Plate 36: Price Creek: View looking upstream.
Note well vegetated, stable banks and bed with stock track.</td><td>Plate 37: Price Creek: Catchment view downstream (watercourse at left) towards Hawkins Creek.
Note change in slope with valley becoming less confined.</td></tr>
<tr><td colspan="2">Channel Geometry: Flat bottomed, continuous, single channel (0.5m wide) with 1.5m high, 1:1.5 (V:H) banks.</td></tr>
<tr><td colspan="2">Planform Geometry: Straight, meanders apparent downstream.</td></tr>
<tr><td colspan="2">Geomorphic Units
• Channel: Incised, single, flat bottomed channel of lower capacity than observed at upstream locations (Price Creek 3 and 4).
• Floodplain: Developed and apparent, no evidence of recent engagement however likely to occur regularly due to lower capacity channel.</td></tr>
<tr><td colspan="2">Bed Condition: Stable, mostly vegetated (grass) though observed to be bare in some sections (exposed gravel).</td></tr>
<tr><td colspan="2">Bank Condition: Stable, vegetated (grass) with established trees at top of bank.</td></tr>
<tr><td colspan="2">Sediment
• Channel: Fine silt, clay, sand and gravel.
• Floodplain: Fine silt and clay.</td></tr>
<tr><td colspan="2">Comment: Stable channel with lower capacity, likely due to decrease in topographic grade and engagement with the floodplain. No evidence of erosion or channel mobility observed.</td></tr>
</table>

Location: Price Creek 6	**Date: 18 July 2017**
Easting: 770057 Northing: 6385707	**AMTD: 0.9km***
Flow condition: No flow.	**Time: 1:55pm**
	
Plate 38: Price Creek: View looking upstream. **Note consistent bank slope suggesting historic mechanical re-alignment to facilitate and direct drainage downstream of contour banks.**	**Plate 39: Price Creek: Catchment view upstream (watercourse at left) towards contour banks.** **Note cleared paddock and low slope.**

Channel Geometry: Single channel “V” drain, (0.5m wide) with 1m high, 1:2 (V:H) banks.

Planform Geometry: Straight, engineered drainage feature.

Geomorphic Units

- **Channel:** Incised, low capacity “V” drain.
- **Floodplain:** Developed and apparent.

Bed Condition: Stable, vegetated (grass).

Bank Condition: Stable, vegetated (grass).

Sediment

- **Channel:** Fine silt, clay and sand.
- **Floodplain:** Fine silt and clay.

Comment: Natural Price Creek watercourse not apparent in this location due to historic clearing and earthworks to facilitate agricultural production. A series of four contour banks have been formed 35 approx.’ 600m upstream from this location and these have significantly disrupted natural discharge from this catchment. The watercourse at this location is an engineered drainage feature which gradually merges with the surrounding pasture to discharge via overland flow.

***** AMTD measured from assumed point of discharge in Hawkins Creek, pastoral activities have overprinted relict watercourse features.

1.10 WALKERS CREEK

1.10.1 Catchment Description

Catchment area: 4.9km^2

Stream order: 3rd (mapping), 2nd (inspection)

AMTD: 2.1km (headwater confluence); northern headwater 1.7km; southern headwater 1.3km.

Elevation: **Headwaters** 750m AHD (northern headwater); **Outlet** 525m AHD

Average grade: 6.5%

Land-use: Predominantly cleared agricultural land (pastoral) with minor forested (native vegetation) on uplands and slopes.

Walkers Creek is an unregulated watercourse that drains a catchment in the western section of the Mine Site in which the proposed Tailings Storage Facility would be situated. Based on the results of the physical inspection the stream order for Walkers Creek (refer Section 1.4), the northern headwater is classified as a 2nd order watercourse, whilst the southern headwater is classified as a 1st order watercourse and subsequently within the Mine Site boundary, Walkers Creek is considered a 2nd order watercourse. The upper reaches of the catchment are generally vegetated and underlain by Permian sediments which are notably scarped whilst the cleared central section of the catchment is, intruded by Permian volcanics. The confluence of the southern and northern headwaters is located at 2.1km AMTD.

The watercourse inspection was conducted on 20 July 2017 along the entire reach of the southern and a section of the northern headwaters, west of Maloneys Road was traversed.

1.10.2 Watercourse Inspection Summary

The watercourse inspection identified that the southern and northern headwaters of Walkers Creek are topographically controlled watercourses which collect runoff from erosional drainage features (i.e. nick points, rock falls and ephemeral, preferential flow paths) formed on the scarped Permian sediments. These northern and southern headwaters only develop typical watercourse features as they traverse the toe of the colluvial fans which have formed at the base of the scarps. These headwaters subsequently merge to form a 2nd order watercourse with a moderate to high capacity incised channel. Historic modifications such as contour banks or shallow drains are notably absent in this catchment with the exceptions being a farm dam situated across the northern headwater approximately 300m north of its confluence with the southern headwater, a 1500mm Reinforced Concrete Pipe (RCP) culvert and another farm dam across a 1st order watercourse below the confluence. This relative absence of hydraulic controls allows for unrestricted catchment discharge which, coupled with land clearing, has led to increased flow velocities and erosion of the valley fill. Whilst the channel of the 2nd order Walkers Creek displays a low sinuosity in the main section of the watercourse, which is likely attributable to an increased bed grade, lateral channel mobility in this section was observed and this was attributed to increased sediment loads from the colluvial uplands.

Subsequently, the southern headwater of the Walkers Creek system is characterised as being a 1st order watercourse in a confined valley setting with occasional floodplain pockets. Whilst the 2nd order northern headwater transitions from a confined valley setting to a partially confined, low sinuosity, planform-controlled system. Below the confluence of the headwaters, the 2nd order Walkers Creek system transitions again into a low sinuosity, gravel bed watercourse in an alluvial valley setting.

1.10.3 Catchment Inspection Results: Walkers Creek

Location: Walkers Creek (southern headwater)	**Date: 19 July 2017**
Flow condition: No flow.	**Time: 10:45am**

Plate 40: Walkers Creek: View looking upstream at head of 1st order watercourse.

Note topographic control and exposed rock.

Plate 41: Walkers Creek: View looking upstream, mid-chainage of (now) 2nd order watercourse.

Note channel is essentially a low capacity, preferential flow path at this location.

Channel Geometry: Single continuous channel, 0.2m – 0.8m wide bed.0.1m – 0.5m 1:2 (V:H) to 1:1 (V:H) banks.

Planform Geometry: Straight, topographically controlled with some outcrop (rock) controls.

Geomorphic Units

- **Channel:** Incised, low capacity channel, no high flow channel developed.

Bed Condition: Stable, vegetated (grass).

Bank Condition: Stable, vegetated (grass).

Sediment: Fine silt, clay, sand, gravel, cobbles and boulders.

Plate 42: Walkers Creek: View looking upstream mid-chainage.

Note increased channel capacity and incised bed.

Comment: Watercourse progressively increases channel capacity in response to increased discharge volume as a consequence of an increase in the contributing catchment. The watercourse in this location is predominantly topographically controlled although some sections are outcrop controlled. Valley fill likely alluvial and colluvial material.

<table>
<tr><td>Location: Walkers Creek (northern headwater)</td><td>Date: 19 July 2017</td></tr>
<tr><td>Flow condition: No flow.</td><td>Time: 10:45am</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Plate 43: Walkers Creek: View looking downstream, northern headwater. Note Nick point at head of 1st order watercourse.</td><td>Plate 44: Walkers Creek: View looking upstream, mid-chainage. Note steep sided banks and bare bed.</td></tr>
<tr><td colspan="2">Channel Geometry: Single continuous channel, 0.2m – 0.8m wide bed.0.1m – 0.5m 1V:2H to 1:1 (V:H) banks.</td></tr>
<tr><td colspan="2">Planform Geometry: Straight, topographically controlled with some outcrop (rock) controls.</td></tr>
<tr><td colspan="2">Geomorphic Units
• Channel: Incised, low capacity channel, no high flow channel developed.</td></tr>
<tr><td colspan="2">Bed Condition: Stable, vegetated (grass) in most sections however some bare sections noted.</td></tr>
<tr><td colspan="2">Bank Condition: Stable, vegetated (grass).</td></tr>
<tr><td colspan="2">Sediment: Fine silt, clay, sand, gravel, cobbles and boulders.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Plate 45: Walkers Creek: View looking upstream mid-chainage
Note shallow low flow channel and evidence of erosion.</td><td>Plate 46: Walkers Creek: View looking downstream towards confluence with southern headwater.
Note lack of channel definition.</td></tr>
<tr><td colspan="2">Comment: Similar to the southern headwater, this watercourse also progressively increases channel capacity in response to increased discharge volume however, due to the construction of a farm dam at the catchment outlet, the channel loses definition (see Plate 48) as a result of reduced discharge. Vegetation changes were noted downstream of the farm dam suggesting possible discharge of shallow groundwater however no flow or pooling was observed.</td></tr>
</table>

Location: Walkers Creek 1	**Date: 19 July 2017**
Easting: 766488 Northing: 6386465	**AMTD: 2.0km**
Flow condition: No flow.	**Time: 10:05am**
	
Plate 47: Walkers Creek: View looking upstream towards confluence of northern and southern headwaters. **Note vertical banks (top centre) and cobbles and boulders in bed (centre).**	**Plate 48: Walkers Creek: View downstream.** **Note change in vegetation, absence of defined channel.**

Channel Geometry:

- **Low Flow Channel**: Discontinuous 1.5m wide shallow channel with 0.5m high, 1:1 (V:H) banks.
- **High Flow Channel:** Discontinuous, broad 10m wide channel with 0.5m high, 1:1 (V:H) banks.

Planform Geometry: Straight, topographically controlled with some outcrop (rock) controls

Geomorphic Units

- **Channel:** Incised, minor development of high flow channel.
- **Riffle:** Approximately 10m long, 1.5m wide. Bed material size suggests high velocity flow.
- **Floodplain:** Developed and apparent.

Bed Condition: Stable, some vegetation, no active erosion apparent.

Bank Condition: Predominantly bare, some minor slumping and blocking observed however not recent.

Sediment

- **Channel:** Sand, gravel, cobbles and boulders.
- **Floodplain:** Fine silt, clay, sand and gravel.

Comment: Combined discharge of both northern and southern 2nd order watercourses and apparent high velocity flow (from bed material) in riffle has led to the formation of a number of geomorphic features at this location. The features lose definition downstream. Whilst vegetation changes are apparent downstream and pooling of standing water was observed, it is unclear as to whether this is attributable to shallow groundwater discharge or hyporheic flow through the unconsolidated alluvial material deposited as valley fill.

Location: Walkers Creek 2	**Date: 19 July 2017**
Easting: 766239 Northing: 6386543	**AMTD: 1.7km**
Flow condition: No flow.	**Time: 9:50am**

Plate 49: Walkers Creek: View looking upstream.

Note bare low flow channel with cobbles and boulders in bed.

Plate 50: Walkers Creek: Standing pool upstream of inspection location.

Channel Geometry:

- **Low Flow Channel**: Continuous 1m wide shallow channel with 0.4m high, 1:2 (V:H) banks.
- **High Flow Channel: C**ontinuous, broad 7m wide channel with 1.5m high, 1:2 (V:H) banks.

Planform Geometry: Curved, outcrop (rock) controlled.

Geomorphic Units

- **Channel:** Incised, well developed high flow channel.
- **Floodplain:** Developed and apparent.

Bed Condition: Stable, some vegetation in low flow which is armoured by angular, sub-angular cobbles and boulders although no imbrication apparent. High flow channel is well vegetated (grass), no active erosion apparent.

Bank Condition: Vegetated (grass), some minor slumping and blocking observed however not recent.

Sediment

- **Channel:** Sand, gravel, cobbles and boulders.
- **Floodplain:** Fine silt and clay (overbank deposits).

Comment: Presence of angular / sub-angular cobbles and boulders in bed suggests relatively high flow velocity although no active erosion was observed, suggesting limited channel migration and hence outcrop (rock) controls)

Location: Walkers Creek 3	**Date: 19 July 2017**
Easting: 765841 Northing: 6386579	**AMTD: 1.2km**
Flow condition: No flow.	**Time: 1:55pm**

Plate 51: Walkers Creek: View looking upstream towards 1500/RCP culvert.

Note vegetation in bed and absence of erosion.

Plate 52: Walkers Creek: Active undercutting, incision and erosion upstream of culvert.

Note bank material, suggesting some reworking of deposited sediment.

Channel Geometry:

- **Low Flow Channel**: Continuous 0.8m wide shallow channel with 0.2m high, 1:2 (V:H) banks.
- **High Flow Channel: C**ontinuous, high capacity, broad 10m wide channel with 2m high, 1:1 (V:H) Left bank and 1:1.5 (V:H) Right bank.

Planform Geometry: Low sinuosity curves, outcrop (rock) controlled.

Geomorphic Units

- **Channel:** Incised, well developed high flow channel.
- **Floodplain:** Developed and apparent.

Bed Condition: Downstream of culvert bed is stable and vegetated (grass) due to the hydraulic control of the culvert. Upstream of the culvert, active erosion occurring, leading to bed incision.

Bank Condition: Downstream of culvert, inner (right) bank well vegetated (grass), whilst outer (left) bank is vertical and bare, with minor slumping and blocking observed. Upstream of culvert, active bank undercutting is occurring leading to lateral mobility of channel.

Sediment

- **Channel:** Sand, gravel, cobbles and boulders.
- **Floodplain:** Fine silt, clay, sand, gravel, cobbles and boulders.

Comment: High capacity and velocity discharge watercourse with active erosion and channel mobility apparent upstream of culvert and road which act as a hydraulic control which attenuates peak discharge downstream, leading to a more stable section of the watercourse. Upstream, it is apparent that the labile sediment material, predominantly derived from sandstone uplands, is being reworked via lateral mobility of the channel.

Location: Walkers Creek 4	**Date: 19 July 2017**
Easting: 765595 Northing: 6386593	**AMTD: 0.9km**
Flow condition: No flow.	**Time: 8:50am**

Plate 53: Walkers Creek: View towards right hand bank.
Note material in exposed bank profile indicating reworking of deposited sediment.

Plate 54: Walkers Creek: View upstream.
Note riffle in foreground, pool in background and wide high flow channel

Channel Geometry:

- **Low Flow Channel**: Continuous 1.5m wide shallow channel with pool and riffles with 1m high, 1:1 (V:H) Left bank and 3m high 1:1 (V:H) Right bank (high flow channel bank).
- **High Flow Channel: C**ontinuous, high capacity, 7m wide channel with 3m high, 1:2 (V:H) Left bank and 1:1 (V:H) Right bank.

Planform Geometry: Low sinuosity curves, sediment controlled.

Geomorphic Units

- **Channel:** Incised, well developed low and high flow channels.
- **Pool:** Approximately 20m long, 3m – 5m wide developed in low flow channel (thalweg) adjacent to Right (outer) bank.
- **Riffle:** Approximately 20m long, 1.5m wide.
- **Floodplain:** Developed and apparent.

Bed Condition: Varying conditions with minor vegetation (grass, reeds) on bar at pool outlet and the remaining sections bare.

Bank Condition: Right hand bank was bare, with angular or sub-angular cobbles and boulders observed, animal burrows (wombat) were also noted. Right hand bank was vegetated (grass) and appeared stable.

Sediment

- **Channel:** Sand, gravel, cobbles and boulders.
- **Floodplain:** Fine silt, clay, sand, gravel, cobbles and boulders.

Comment: High capacity, single continuous channel. Exposed bank material indicates historic mobility however established grass cover on some banks suggests that this is no longer occurring. A number areas of historic bank erosion were observed however the establishment of vegetation precluded the identification of the cause of the erosion which could be attributed to animal disturbance (wombat burrows) or piping failure from the entry of discharge from the 1st order drainage feature situated to the north of this location. Discharge from this 1st order drainage feature is presently intercepted by a farm dam with a 2m embankment.

Location: Walkers Creek 5	**Date: 19 July 2017**
Easting: 765421 Northing: 6386569	**AMTD: 0.8km**
Flow condition: No flow.	**Time: 8:30am**

Plate 55: Walkers Creek: View downstream.

Note cobbles and boulders in channel bed and vegetated high flow channel.

Plate 56: Walkers Creek: View towards right hand bank.

Note exposed bank material, evidence of undercutting and stock paths.

Channel Geometry:

- **Low Flow Channel**: Continuous, broad, shallow 1.5m wide channel with 0.5m -0.8m high, 1:1 (V:H) banks.
- **High Flow Channel: C**ontinuous, high capacity, 8m – 9m wide channel with 2.5m high, 1:1.5 (V:H) Right bank and Left bank which transitions from 1:2 (V:H) to 1:1 (V:H).

Planform Geometry: Straight, incised.

Geomorphic Units

- **Channel:** Incised, well developed low and high flow channels.
- **Floodplain:** Developed and apparent.

Bed Condition: Varying with some sections bare (potentially a poorly developed pool and riffle sequence) with other sections vegetated (grass).

Bank Condition: Right hand bank was vegetated (grass) in places although some rill erosion was observed. Left hand bank was vegetated (grass) although top (vertical) section was bare and evidence of undercutting was observed.

Sediment

- **Channel:** Fine silts**,** sands**,** gravel, cobbles and boulders.
- **Floodplain:** Fine silt, clay, sand, gravel, cobbles and boulders.

Comment: High capacity, single continuous channel that presents as deep erosional feature. Exposed bank angular and sub-angular material indicates historic deposition and subsequent reworking as a result of historic channel mobility. Banks are further degraded at this location as a result of stock paths and animal (wombat) disturbance.

2. BASELINE WATER QUALITY ASSESSMENT

2.1 INTRODUCTION

Similar to geomorphology, the constituent concentrations of the range of physico-chemical parameters present in the discharge of a particular catchment is typically influenced by a combination of factors such as:

- catchment geology which influences the nature and type interactions between rock (e.g. groundwater discharge, weathering), rainfall and runoff and subsequently water chemistry;
- catchment land use and vegetation cover which influences the water chemistry; and
- climate influences the type of climatic environment influences the weathering regime of the host geology and consequently the sediment type, particularly the clay fraction whilst the frequency and duration of rainfall events influences the timing of peak discharge in a catchment that subsequently influences the transport of material either to or within a given watercourse which also influences the water chemistry (e.g. "first flush events").

Monitoring and sampling for ambient surface water quality in Hawkins and Lawsons Creeks and their tributaries has been undertaken since 2012 to enable the characterisation of the upstream, downstream and mid-chainage water quality in the vicinity of the Mine Site. The reporting of sampled results to characterise the water quality is undertaken with reference to 20th, 50th and 80th percentile bands and box and whisker plots have been compiled and used to present the results. This type of plot is extremely useful in providing a visual representation of the statistical interpretations recommended in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018) for checking data distribution to inform this condition assessment. All plots present data as maximum, minimum, median, 20th and 80th percentiles. The median has been chosen for comparison to trigger values as a means of characterising the water quality. This is the approach recommended in ANZG (2018) and intended as a mechanism to characterise the subject watercourses in recognition of historic catchment alteration to facilitate agricultural land use and the geology of the contributing catchment.

In August 2019, Bowdens Silver conducted a round of stream sediment sampling in Hawkins and Lawsons Creeks in the vicinity of Bowdens Silver's surface water monitoring locations to identify the baseline chemical composition of these sediments within these creeks. In addition, leachate testing was undertaken on the sampled sediments to understand the readily mobilised solutes from the sediment. This section presents the results of the leachate tests conducted on sediment samples:

- within Hawkins Creek, upstream and downstream of the Mine Site; and
- within Lawsons Creek, upstream of Hawkins Creek and downstream of Lue.

2.2 WATER QUALITY OBJECTIVES

The principal guideline for water quality in Australia is ANZG (2018). Much of ANZG (2018) relies upon guidance developed by the Australian and New Zealand Environment and Conservation Council (ANZECC) in collaboration with the Agriculture and Resources Management Ministerial Council of Australia and New Zealand (ARMCANZ) and which was published in the (then) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000). ANZG (2018) sets quantitative and qualitative values for a range of water quality parameters for the protection of aquatic ecosystems, aquaculture, recreation, drinking and agricultural values.

The receiving environment in the vicinity of the Mine Site and downstream holds a range of water quality objectives reflecting the ecological, social and economic attributes and ecosystem function of the catchment in which they are situated. The identification of the water quality objectives helps determine the specific water quality trigger values which need to be maintained.

A description of the water quality objectives for the Macquarie Bogan River catchment, as identified by the NSW Environment, Energy and Science (EES) Group (formerly Office of Environment and Energy) for the receiving environment downstream from the Mine Site is summarised below.

Aquatic Ecosystem

- Maintaining or improving the ecological condition of waterbodies and their riparian zones over the longer term.

Visual Amenity

- Aesthetic quality of waters.

Primary Contact Recreation

- Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed.

Secondary Contact Recreation

- Maintaining or improving water quality for activities such as boating and wading in which there is a low probability of water being swallowed.

Livestock Water Supply

- Protecting water quality to maximise the production of healthy livestock.

Irrigation Water Supply

- Protecting the quality of waters applied to crops and pasture.

Homestead Water Supply

- Protecting water quality for domestic use in homesteads including drinking, cooking and bathing.

Drinking Water (disinfection only or clarification and disinfection)

- Protecting the quality water at, and upstream of, offtake points for town water supply and specific sections of rivers that contribute to drinking water storages.

Aquatic Foods (cooked)

- Protecting water quality so that it is suitable for the production of aquatic foods for human consumption and aquaculture activities.

Where more than one water quality objective is identified for a specific water resource, the more conservative water quality objective has been adopted as the appropriate trigger value in order to assess the water quality. Consequently, water quality trigger values for the assessment of the waters are based primarily on the relevant guideline values that have been developed for the aquatic ecosystem water quality objective. **Table 3** contains the adopted trigger values for the water quality objectives relevant to upland streams in the Macquarie Bogan River catchment.

Table 3
Guideline Trigger Values for Surface Water

Parameters	Unit	Trigger Value
Nutrients		
Ammonia as N*	mg/L	0.013[1]
Nitrate*	mg/L	0.015[1]
Total N*	mg/L	0.250[1]
Total P*	mg/L	0.020[1]
Physico-chemical		
pH	-	6.5-8.0[2]
Sulphate*	mg/L	1 000[3]
Electrical Conductivity	µS/cm	30-350[1]
Dissolved Metals		
Arsenic*	mg/L	0.013[1]
Cadmium*	mg/L	0.0002[1]
Cobalt*	mg/L	Insufficient Data[1]
Copper*	mg/L	0.0014[1]
Iron*	mg/L	Insufficient Data[1]
Lead*	mg/L	0.0034[1]
Manganese*	mg/L	1.9[1]
Nickel*	mg/L	0.011[1]
Zinc*	mg/L	0.008[1] and 0.005[4]

* Guideline values relate to comparison with the 50th percentile or median value of the results
1 ANZG Aquatic ecosystem protection
2 OEH NSW Aquatic ecosystem protection (Macquarie-Bogan Water Quality Objectives)
3 ANZG Livestock drinking water quality
4 OEH NSW Aquatic Foods (cooked) protection (Macquarie-Bogan Water Quality Objectives)

2.3 SURFACE WATER SAMPLING LOCATIONS

A total of 10 locations along the subject watercourses were sampled by Kingsgate Bowdens Pty Ltd or Bowdens Silver between June 2012 and November 2018 with the data utilised for the purposes of this assessment. The sampling locations are listed in **Table 4** and presented on **Figure 5**.

Table 4
Surface Water Monitoring Locations

Location Ref	Watercourse / Catchment	Position
BSW 13	Hawkins Creek	Upstream of Mine Site Boundary
BSW 11*	Hawkins Creek	Adjacent to Mine Site Boundary
BSW 7	Hawkins Creek	Adjacent to Mine Site Boundary
BSW 12	Hawkins Creek	Downstream of Mine Site Boundary
BSW 19*	Hawkins Creek	Downstream of Mine Site Boundary
BSW 20*	Lawsons Creek	Upstream of Hawkins Creek confluence
BSW 21	Lawsons Creek	Downstream of Hawkins Creek confluence
BSW 22	Lawsons Creek	Downstream of Lue
BSW 28*	Lawsons Creek	Downstream of Lue
BSW 25	Tributary (Lawsons Creek)	West of Mine Site
BSW = Bowdens Surface Water		* Stream sediment sample also collected at this location

2.4 ANALYTES

The sampling locations listed in **Table 4** were generally sampled on a monthly basis and submitted to a NATA accredited laboratory for analysis of the physico-chemical parameters shown in **Table 3**. In total, the dataset comprises 11,904 individual analytical results from a suite of 29 analytes.

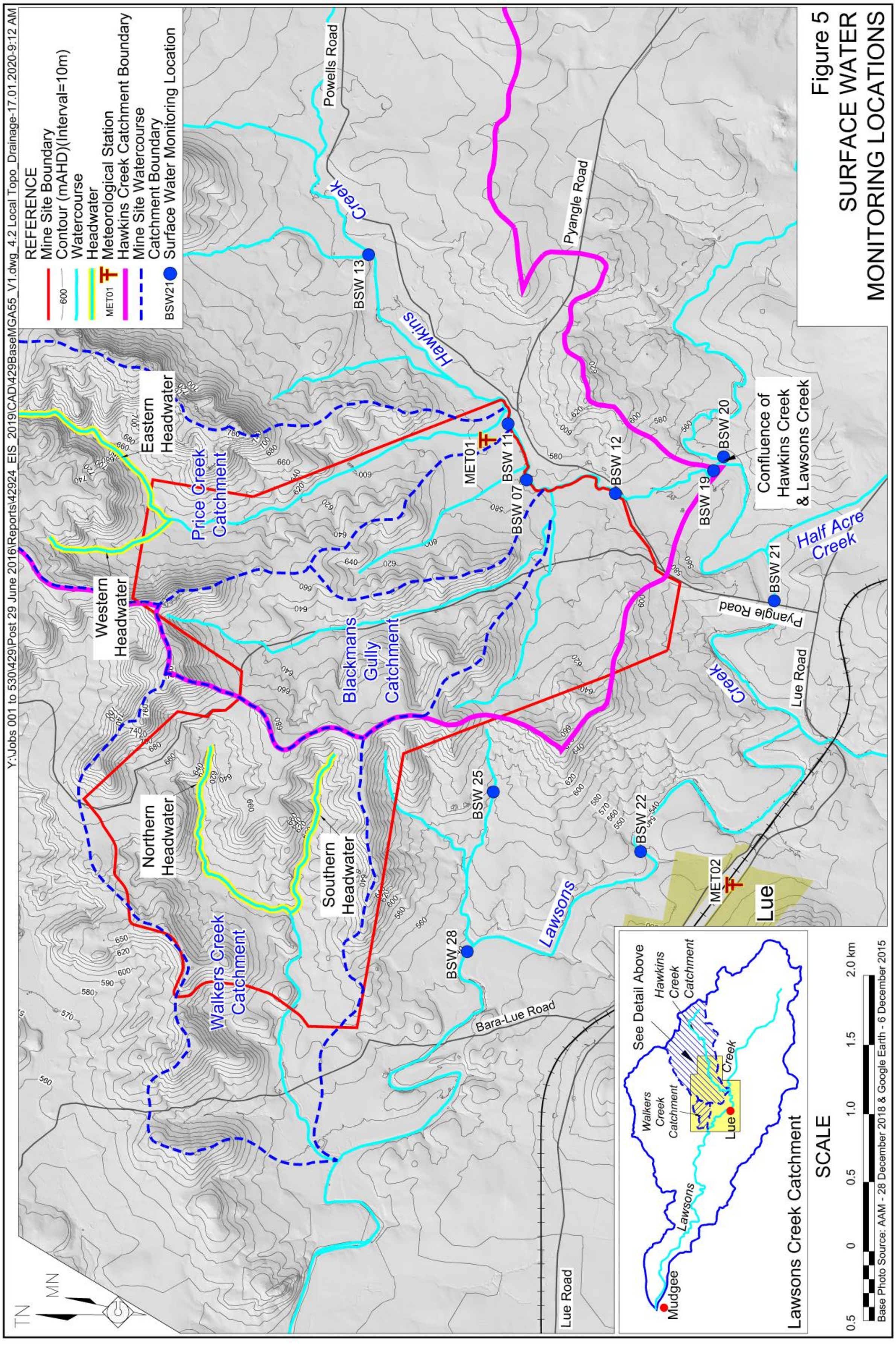
2.5 RESULTS AND INTERPRETATION

2.5.1 Data Presentation

2.5.1.1 Surface Water Quality

Box and whisker plots have been compiled and used to present the results of water quality monitoring for this assessment. This type of plot is extremely useful in providing a visual representation of the statistical distribution of a sample population. With the exception of electrical conductivity, which reports the 75th percentile value, all plots present data as maximum, minimum, median, 20th and 80th percentiles. With regard to electrical conductivity, the use of the 75th percentile, rather than the 80th percentile has been adopted as with this indicator the 80th percentile is usually significantly higher than the median and allows for too much change when compared to the median (EHP, 2009). The median has been chosen for comparison to trigger values. This is the approach recommended in ANZG. This approach is not intended as being an instrument to assess compliance but as an early warning mechanism for the management of potential impacts.

Figure 5 Surface Water Monitoring Locations



With the exception of Bowdens Surface Water (BSW) 25, which is the lone sampling location on a minor 1st order watercourse that discharges into Lawsons Creek west of the Mine Site, the data presented in Section 2.6.2 is organised so that monitoring locations are grouped by watercourse (Hawkins Creek or Lawsons Creek) with the most downstream sampling location positioned nearest to the left of the x-axis (Hawkins Creek = BSW 19; Lawsons Creek = BSW 28) with increasing distance from that sampling location reflected along the right of the x-axis. A discussion of the results follows the presentation of all data sets.

The sites referred to in the plots are those shown in **Figure 5** and listed in **Table 4**.

The results of the statistical analyses and a table listing the sample populations and number of samples that were below the limit of laboratory detection (limit of reporting [LOR]) for each sampling location is also provided. The LOR for each analyte is presented in the statistical summaries in Appendix 1. Statistical analyses were not performed where sampled populations did not record more than ten results were above the LOR and are left blank on the plots. As this is a baseline assessment and due to the catchment size and potential to influence water quality from multiple diffuse points within the catchment, the discussion accompanying the presentation of monitoring data is kept brief. Section 2.5.2 presents the results for each of the following analytes;

- ammonia
- total nitrogen
- pH
- electrical conductivity
- nitrate
- total phosphorous
- sulphate
- dissolved metals (arsenic, cadmium, cobalt, copper, iron, lead manganese, nickel and zinc)

Full statistical analyses of all monitoring data are presented in **Attachment 1**.

2.5.2 Results

2.5.2.1 Surface Water

Nutrients

The elevated concentrations of nitrogenous and phosphorous compounds described below may be attributable to the following aspects which relate to the principal land use of the contributing catchment being pastoral, namely:

- the application of nitrogenous and / or phosphatic fertilisers to facilitate pasture growth to sustain livestock production; and
- transport of nutrients adsorbed onto mineral surfaces.

However, two other potential contributions to the recorded nutrients concentrations may also be factors and are:

- the decay of organic materials, notably as the result of the vegetation becoming established in the channel of both Hawkins and Lawsons Creeks; and
- septic systems.

Ammonia

Figure 6 identifies that the median values (50th percentile) for ammonia exceed the trigger value range at all monitoring locations. The variance in samples above the LOR (**Table 5**) may be attributable to variation in flow events.

Figure 6 Monitoring Results: Ammonia

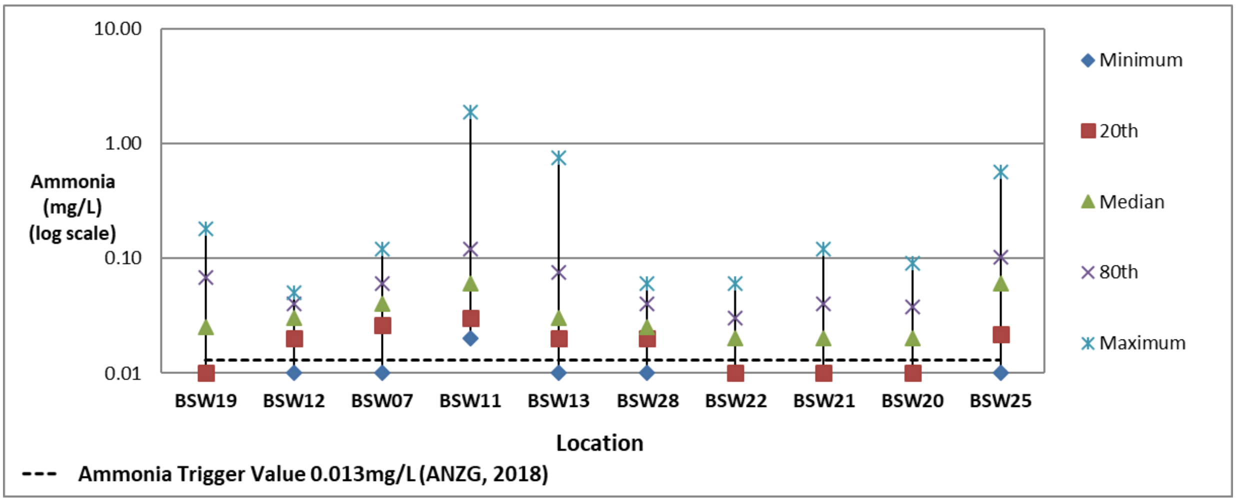


Table 5
Sample Population and Samples Below LOR: Ammonia

Location	**BSW19**	**BSW12**	**BSW07**	**BSW11**	**BSW13**	**BSW28**	**BSW22**	**BSW21**	**BSW20**	**BSW25**
Sample population	24	44	47	39	43	29	38	45	39	25
Above LOR	12	21	32	29	23	16	26	31	27	20
Below LOR	12	23	15	10	20	13	12	14	12	5
% Below LOR	50%	52%	32%	26%	47%	45%	32%	31%	31%	20%

Nitrate

Similar to ammonia, the median values (50th percentile) for nitrate exceed the trigger value at all monitoring locations (**Figure 7**). The variation in the results above LOR (**Table 6**) of nitrate are also likely attributable to the factors outlined for ammonia.

Figure 7 Monitoring Results: Nitrate

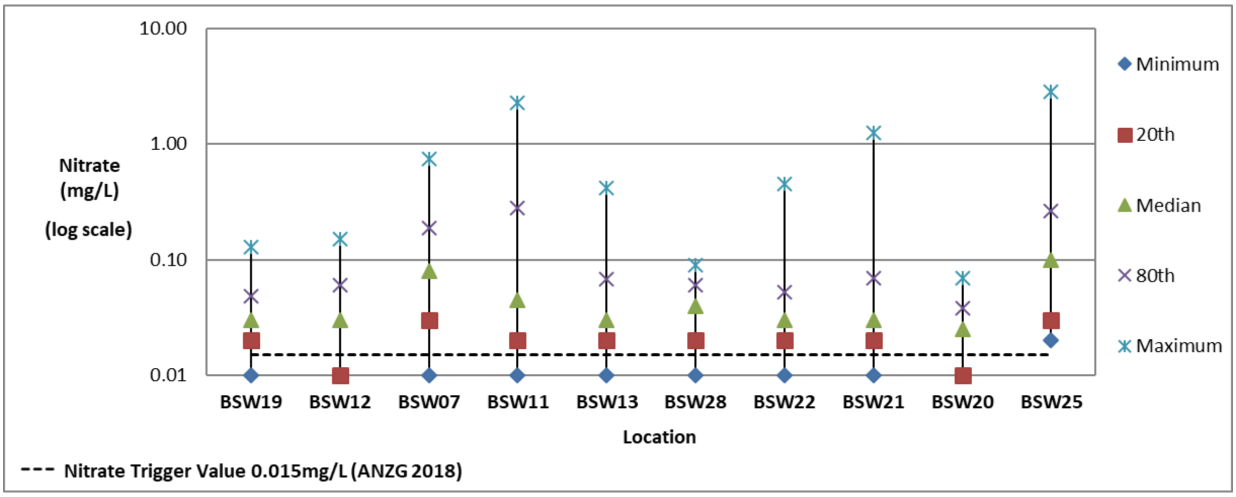


Table 6
Sample Population and Samples Below LOR: Nitrate

Location	BSW19	BSW12	BSW07	BSW11	BSW13	BSW28	BSW22	BSW21	BSW20	BSW25
Sample population	24	44	47	39	43	29	38	45	39	25
Above LOR	14	21	44	30	19	16	18	26	22	19
Below LOR	10	23	3	9	24	13	20	19	17	6
% Below LOR	42%	52%	6%	23%	56%	45%	53%	42%	44%	24%

Total Nitrogen

The median values (50th percentile) for total nitrogen are above the trigger value at all monitoring locations. Review of sampled results for total nitrogen and total Kjeldahl nitrogen, an analytical method for measuring organic nitrogen, identified that the increased number of sampled results for total nitrogen that were above LOR (**Table 7**) could be attributed to organic nitrogen (**Figure 9**) that was present at concentrations above the LOR in 97% of samples (**Table 8**).

Figure 8 Monitoring Results: Total Nitrogen

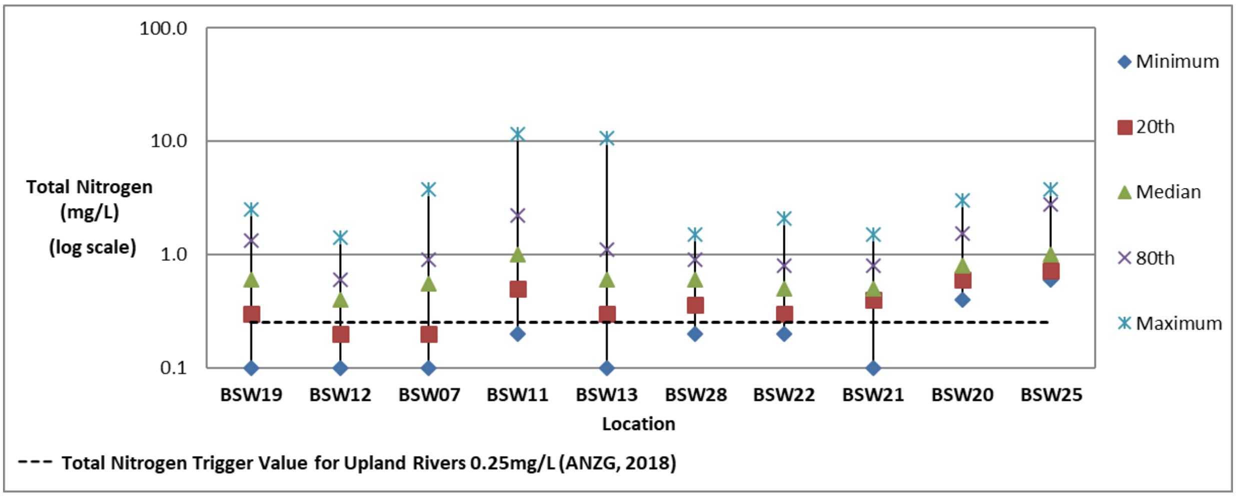


Table 7
Sample Population and Samples Below LOR: Total Nitrogen

Location	BSW19	BSW12	BSW07	BSW11	BSW13	BSW28	BSW22	BSW21	BSW20	BSW25
Sample population	24	44	47	39	43	29	38	45	39	25
Above LOR	24	39	44	38	43	29	38	45	39	25
Below LOR	0	5	3	1	0	0	0	0	0	0
% Below LOR	0%	11%	6%	3%	0%	0%	0%	0%	0%	0%

Figure 9 Monitoring Results: Total Kjeldahl Nitrogen

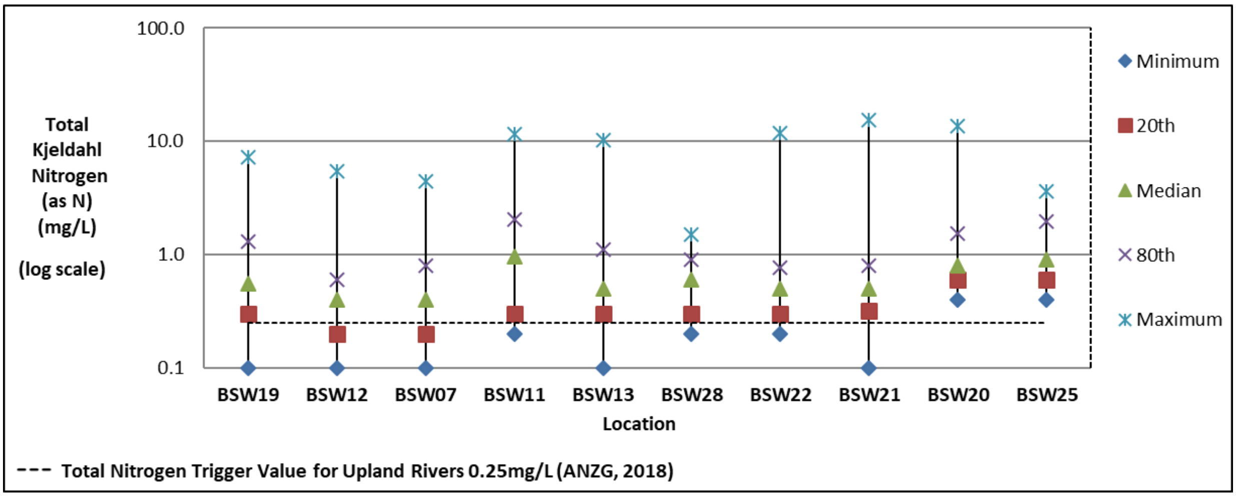


Table 8
Sample Population and Samples Below LOR: Total Kjeldahl Nitrogen

Location	BSW19	BSW12	BSW07	BSW11	BSW13	BSW28	BSW22	BSW21	BSW20	BSW25
Sample population	24	44	47	39	43	29	38	45	39	25
Above LOR	24	39	43	38	43	29	38	45	39	25
Below LOR	0	5	4	1	0	0	0	0	0	0
% Below LOR	0%	11%	9%	3%	0%	0%	0%	0%	0%	0%

Total Phosphorous

The median values (50th percentile) for total phosphorous exceed the trigger value at all sampling locations (**Figure 10**). Similar to total nitrogen, compared to ammonia and nitrate, an increased number of sampled results are above LOR (**Table 9**) suggesting a consistent contribution to catchment watercourses is occurring.

Figure 10 Monitoring Results: Total Phosphorous

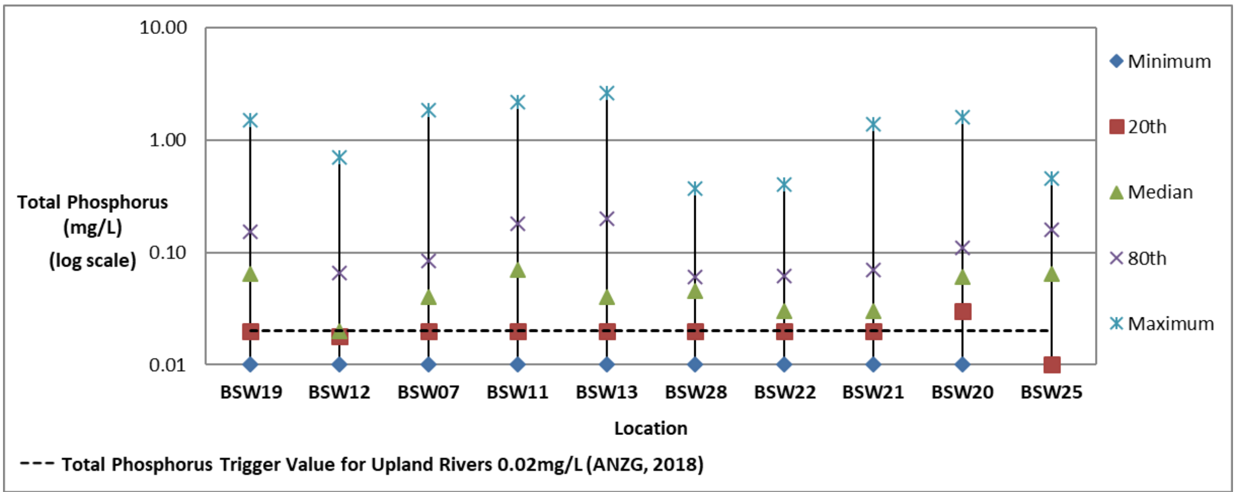


Table 9
Sample Population and Samples Below LOR: Total Phosphorous

Location	BSW19	BSW12	BSW07	BSW11	BSW13	BSW28	BSW22	BSW21	BSW20	BSW25
Sample population	24	44	47	39	43	29	38	45	39	25
Above LOR	22	28	40	34	36	28	35	39	36	22
Below LOR	2	16	7	5	7	1	3	6	3	3
% Below LOR	8%	36%	15%	13%	16%	3%	8%	13%	8%	12%

With respect to Lawsons Creek, the highest median nitrate and ammonia concentrations are observed at the same monitoring location (BSW 21), which is downstream of the Lawsons Creek confluence with Hawkins Creek as well as another, unnamed watercourse which conveys discharge from a catchment to the southeast. The highest median nitrate concentrations for those monitoring locations on Hawkins Creek was recorded at BSW 7, which is downstream of BSW 11 (highest median ammonia) although both BSW 7 and BSW 11 have returned the highest nitrate concentrations. The land use of the catchment in the vicinity of both BSW 7 and BSW 11 is predominantly pastoral and both BSW 7 and BSW 11 are downstream of Price Creek with discharge from this catchment potentially influencing nitrate concentrations.

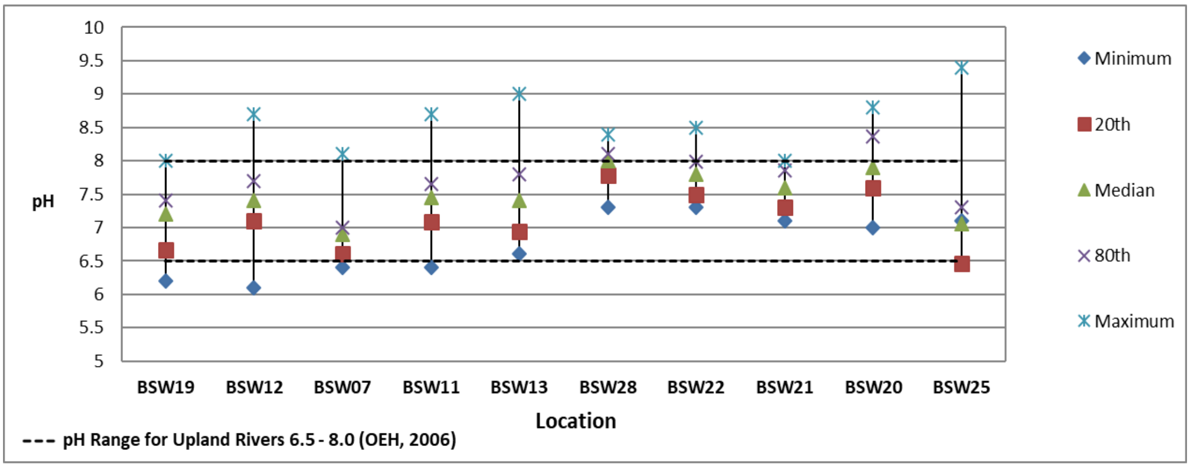
It should be noted however, that the general trend of a decrease in the concentration of nitrogenous compounds with increasing distance from the Mine Site is a situation not matched by the concentrations of total phosphorous. Conversely, the concentration of total phosphorous to those observed at BSW 20 (Lawsons Creek) and BSW 11 (Hawkins Creek) return to similar values at the furthermost monitoring locations, BSW 28 and BSW 19 respectively downstream from the Mine Site.

Physico-chemical

<u>pH</u>

The range of calculated medians for the results of sampling at all monitoring locations indicates that pH is within the required range for upland rivers (**Figure 11**). The results for monitoring locations on Lawsons Creek are generally at the upper end of this range. It is notable that the maxima recorded at BSW 22, BSW 13 and BSW 12 all occurred during the sampling event conducted on 3 February 2016, however, a similar pH value was not recorded at BSW 21 on the same date, suggesting that the values recorded are not the result of equipment malfunction or sampling error.

Figure 11 Monitoring Results: pH



Given that pH is a measure of hydrogen activity, it is unsurprising that pH was recorded for all samples collected and subsequently no tabulation of sample populations is provided for pH.

<u>Sulphate</u>

The results of sampling for sulphate at all monitoring locations identifies that sulphate concentrations are below the trigger value (**Figure 12**). Sulphate was invariably reported above the LOR for almost all sampling rounds at all locations **Table 10**). It is notable that the calculated median values for those monitoring locations on Hawkins Creek, in the vicinity, and downstream of, the ore body (i.e. BSW 19, BSW 12 and BSW 7) and therefore the area of sulphide mineralisation (and potential oxidation of sulphide to sulphate) are lower than those recorded at monitoring locations within Lawsons Creek.

Figure 12 Monitoring Results: Sulphate

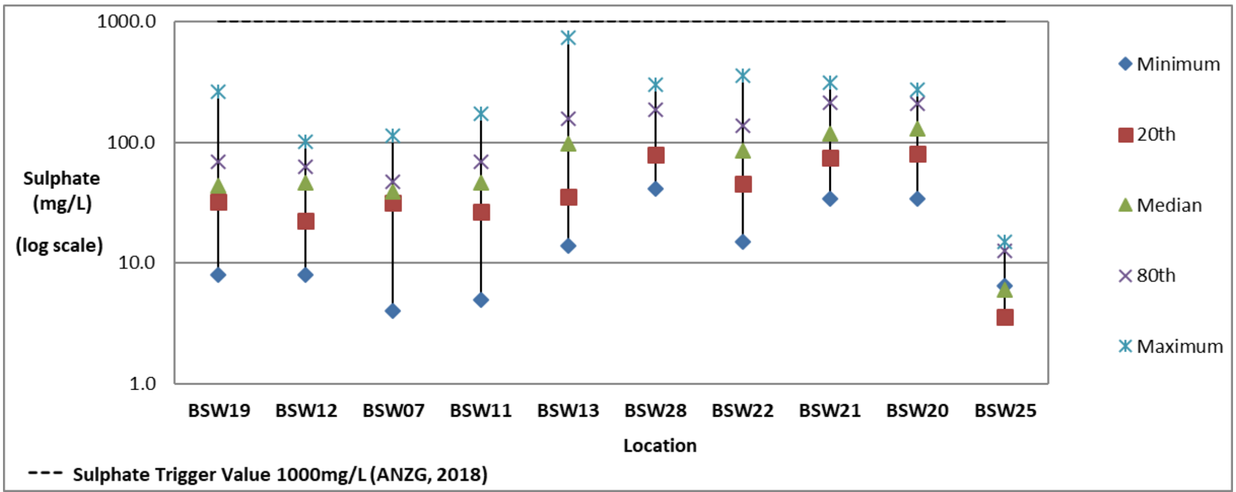


Table 10
Sample Population and Samples Below LOR: Sulphate

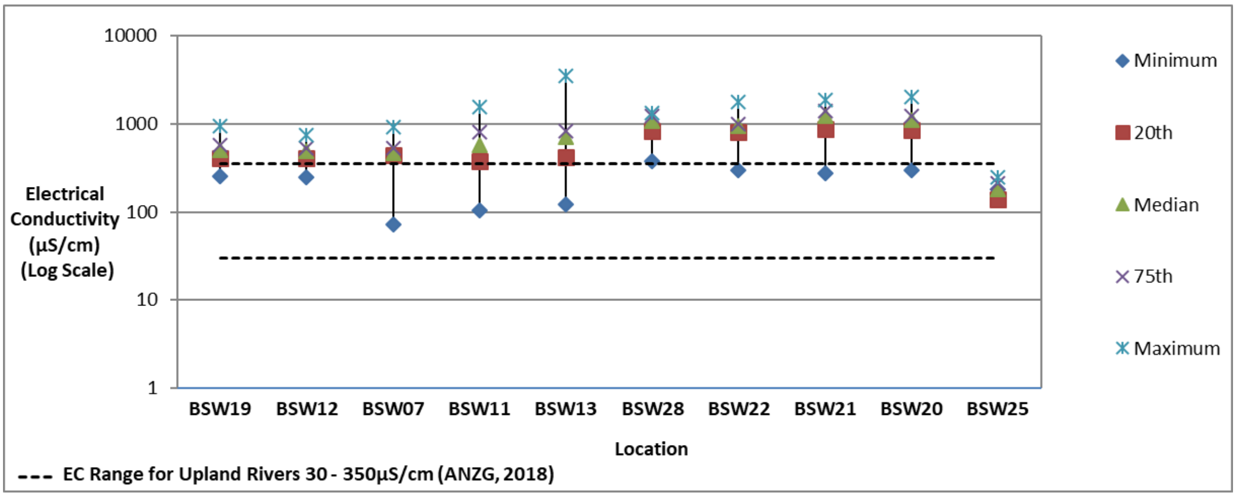
Location	**BSW19**	**BSW12**	**BSW07**	**BSW11**	**BSW13**	**BSW28**	**BSW22**	**BSW21**	**BSW20**	**BSW25**
Sample population	30	51	54	46	50	29	45	52	45	25
Above LOR	30	51	54	46	50	29	45	52	45	15
Below LOR	0	0	0	0	0	0	0	0	0	10
% Below LOR	0%	0%	0%	0%	0%	0%	0%	0%	0%	40%

<u>Electrical Conductivity</u>

The range of the results of sampling for electrical conductivity at all monitoring locations indicates that the values for this parameter are above the range for upland rivers (**Figure 13**).

This may be attributable to factors such as the land use of the contributing catchment leading to increase solutes and sediment in the surface water, changes to the prevailing hydrological regime leading to the formation of discontinuous pools and the establishment of vegetation in the channels of the watercourses (leading to increased biological activity) or natural causes related to the underlying geology and vegetation on the uplands.

Figure 13 Monitoring Results: Electrical Conductivity



Given that electrical conductivity is a measure of dissolved solutes, it is unsurprising that electrical conductivity was recorded in natural waters and for all samples collected. Subsequently, no tabulation of sample populations is provided for electrical conductivity.

Dissolved Metals

<u>Arsenic</u>

The results of sampling for arsenic and the results of the statistical analyses shown on **Figure 14** indicate that the concentration of arsenic is well below the trigger value at all monitoring locations. It is notable that of those monitoring locations located in Hawkins Creek, only BSW 11 returned results above LOR on ten occasions (**Table 11**) with all other Hawkins Creek monitoring locations recording result below LOR for >85% of samples (**Table 11**). Monitoring locations in Lawsons Creek returned a higher number of samples above LOR, allowing for the calculations of statistics. This notwithstanding, the median arsenic concentrations are all within a very narrow range between 0.003mg/L and 0.006mg/L.

Figure 14 Monitoring Results: Dissolved Arsenic

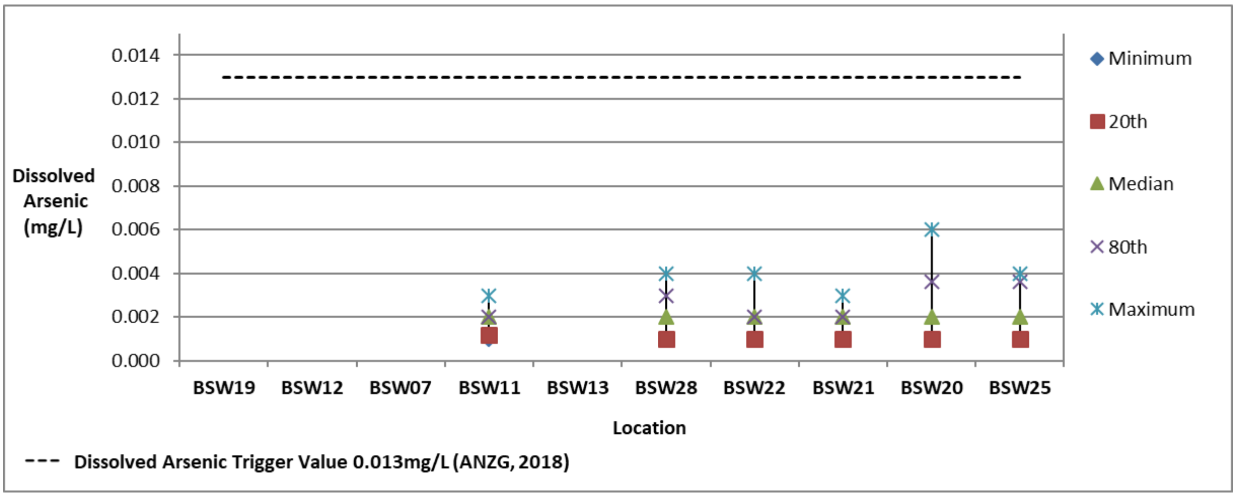


Table 11
Sample Population and Samples Below LOR: Dissolved Arsenic

Location	**BSW19**	**BSW12**	**BSW07**	**BSW11**	**BSW13**	**BSW28**	**BSW22**	**BSW21**	**BSW20**	**BSW25**
Sample population	30	51	54	46	50	29	45	52	45	25
Above LOR	4	4	4	10	3	18	22	21	23	13
Below LOR	26	47	50	36	47	11	23	31	22	12
% Below LOR	87%	92%	93%	78%	94%	38%	51%	60%	49%	48%

Cadmium

In the absence of any monitoring location returning more than ten results for dissolved cadmium that are above the LOR (**Table 12**), **Figure 15** presents the maximum value recorded. With the exception of BSW 11, no monitoring location returned a result above LOR on more than one sampling round (**Table 12**). With regards to BSW 21, the values shown are considered anomalous and are based on the results of one sampling round (20 June 2013) where the limit of reporting is recorded by the laboratory as being 0.001mg/L whereas all other results for cadmium for this round state the limit of reporting as being 0.0001mg/L. With the exception of BSW 21, the results of sampling for cadmium and the maximum results of the statistical analyses indicate that the concentration of cadmium is at or below the trigger value which is just above the limit of reporting (0.0001mg/L).

Figure 15 Monitoring Results: Dissolved Cadmium (maximum values)

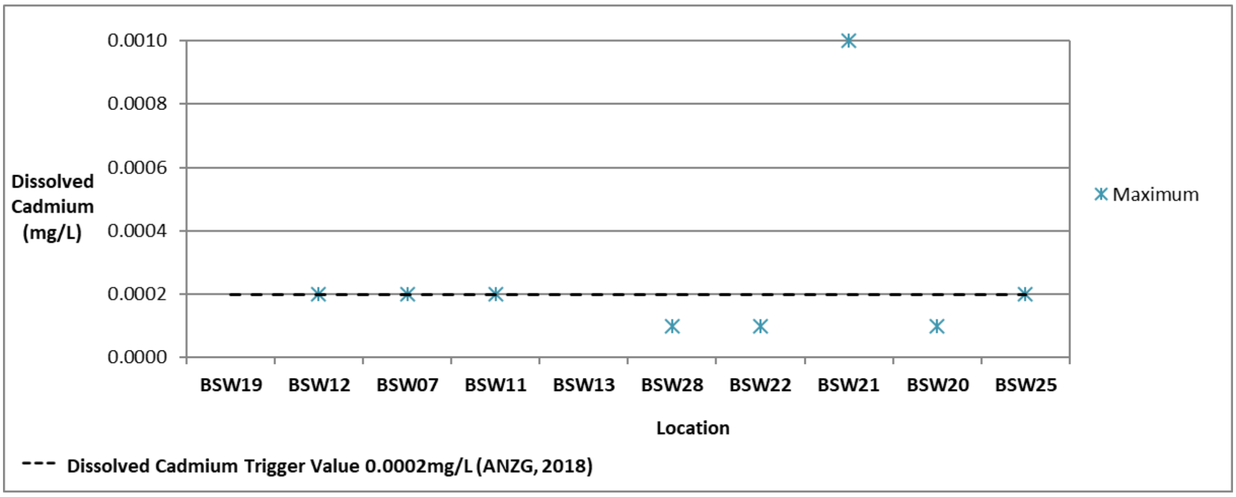


Table 12
Sample Population and Samples Below LOR: Dissolved Cadmium

Location	**BSW19**	**BSW12**	**BSW07**	**BSW11**	**BSW13**	**BSW28**	**BSW22**	**BSW21**	**BSW20**	**BSW25**
Sample population	30	51	54	46	50	29	45	52	45	25
Above LOR	0	1	1	3	0	1	1	1	1	1
Below LOR	30	50	53	43	50	28	44	51	44	24
% Below LOR	100%	98%	98%	93%	100%	97%	98%	98%	98%	96%

Cobalt

With the exception of monitoring locations BSW 7, BSW 11, BSW 13 and BSW 25, all of which are situated on Hawkins Creek, no monitoring locations recorded more than ten results that were above the LOR (**Figure 16**, **Table 13**). The results of the statistical analyses indicate that the median concentration of cobalt for all monitoring locations is within a relatively narrow range (0.001mg/L to 0.003mg/L).

Figure 16 Monitoring Results: Dissolved Cobalt

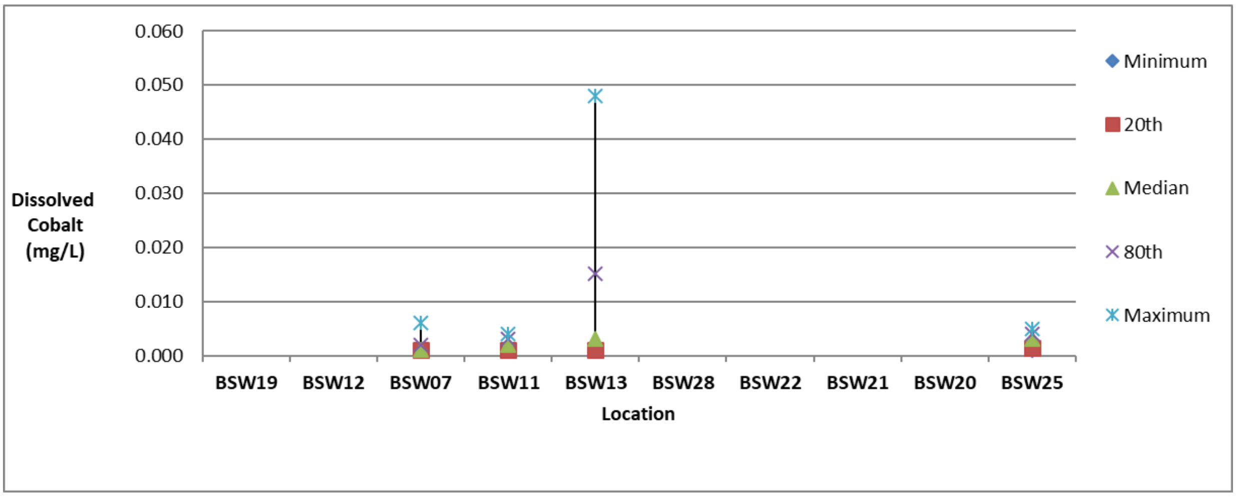


Table 13
Sample Population and Samples Below LOR: Dissolved Cobalt

Location	BSW19	BSW12	BSW07	BSW11	BSW13	BSW28	BSW22	BSW21	BSW20	BSW25
Sample population	24	44	47	39	43	29	38	45	39	25
Above LOR	9	3	10	12	33	1	1	1	5	11
Below LOR	15	41	37	27	10	28	37	44	34	14
% Below LOR	63%	93%	79%	69%	23%	97%	97%	98%	87%	56%

The maxima recorded at BSW 7 (19 March 2013), BSW 11 (15 November 2017) and BSW 13 (17 May 2017) were the result of different rounds of sampling and are considered as being representative of a temporal variation in cobalt concentrations although, based on the sample populations and monitoring locations, the spatial variation is limited. It is notable that elevated cobalt concentrations are not recorded during the same sampling round at the subsequent monitoring location either upstream or downstream.

Copper

The results at monitoring locations BSW 19, BSW 28 and BSW 25 did not return more than ten values above LOR (**Table 14**) however, as shown on **Figure 17,** with the exception of BSW 12 and BSW 21, the median concentration of copper at all monitoring locations is above the trigger value. This notwithstanding, the median copper concentrations at all monitoring locations are within a relatively narrow range (0.001mg/L to 0.002mg/L).

Figure 17 Monitoring Results: Dissolved Copper

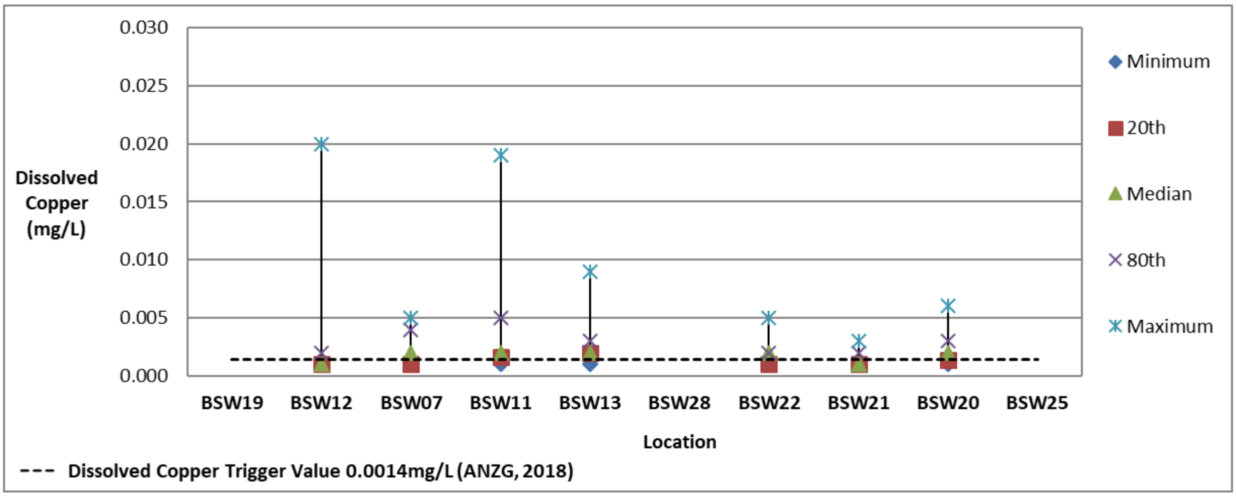


Table 14
Sample Population and Samples Below LOR: Dissolved Copper

Location	BSW19	BSW12	BSW07	BSW11	BSW13	BSW28	BSW22	BSW21	BSW20	BSW25
Sample population	30	51	54	46	50	29	45	52	45	25
Above LOR	8	13	14	27	23	6	14	16	26	7
Below LOR	22	38	40	19	27	23	31	36	19	18
% Below LOR	73%	75%	74%	41%	54%	79%	69%	69%	42%	72%

The maxima recorded at BSW 13 and BSW 11 (4 February 2015), were recorded during the same round of sampling whilst that maximum recorded at BSW 12, downstream of BSW 13 and BSW 11, occurred on 18 October 2012. Again, it is notable that an elevated copper concentration was not recorded during the same sampling round at the downstream monitoring location on 4 February 2015 however, despite temporal variation, the spatial distribution of these results are restricted to Hawkins Creek.

<u>Lead</u>

Similar to cadmium, in the absence of any monitoring location returning more than ten results for dissolved lead that are above the LOR (**Table 15**), **Figure 18** presents the maximum value recorded. As shown on **Table 15**, Hawkins Creek monitoring locations BSW 19, BSW 12 and BSW 7 did not return any samples above LOR, with Lawsons Creek monitoring locations BSW 22 and BSW 21 also not returning results above LOR. Of those monitoring locations that did return samples above LOR, none returned more than two samples above the LOR. With the exception of monitoring locations BSW 11 (Hawkins Creek) and BSW 20 (Lawsons Creek), the maximum result for lead at each monitoring location were below the trigger value. However, carbonate complexation can influence lead toxicity and calculation of the hardness modified trigger values for BSW 11 (HMTV 0.0189mg/L) and BSW 20 (0.074mg/L) identify that the maxima recorded at BSW 11 (0.007mg/L) and BSW 20 (0.005mg/L) were below these modified trigger values. These two maxima were recorded at monitoring locations with no hydraulic connection (BSW 11 is situated on Hawkins Creek whilst BSW 20 is situated on Lawsons Creek, upstream of the confluence with Hawkins Creek), suggesting there is spatial variability on sources that may contribute to the presence of lead in these watercourses.

Figure 18 Monitoring Results: Dissolved Lead

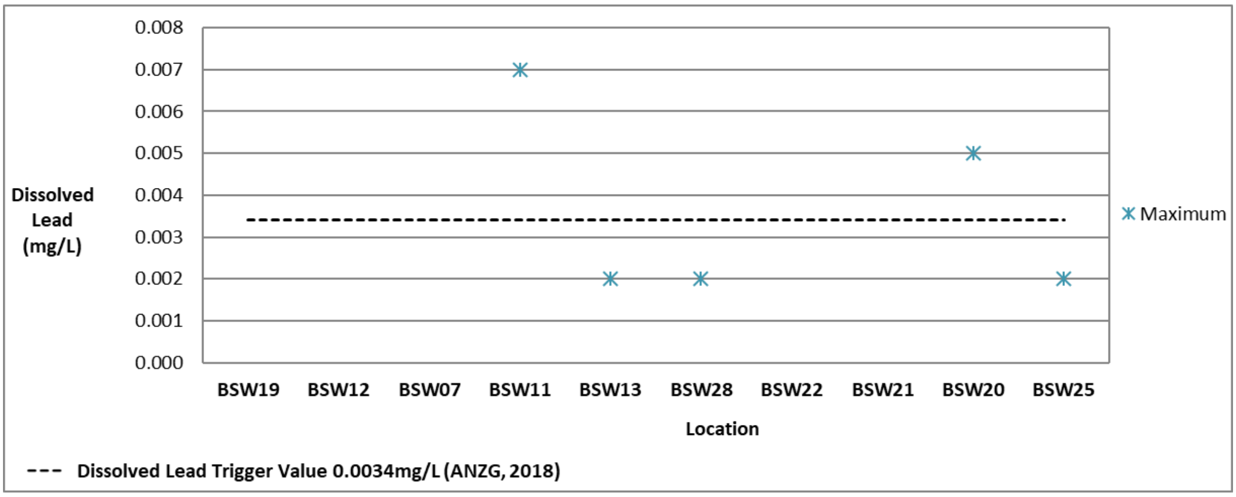


Table 15
Sample Population and Samples Below LOR: Dissolved Lead

Location	BSW19	BSW12	BSW07	BSW11	BSW13	BSW28	BSW22	BSW21	BSW20	BSW25
Sample population	30	51	54	46	50	29	45	52	45	25
Above LOR	0	0	0	1	2	1	0	0	2	2
Below LOR	30	51	54	45	48	28	45	52	43	23
% Below LOR	100%	100%	100%	98%	96%	97%	100%	100%	96%	92%

Manganese

Like iron, manganese is an essential element for organisms which can be bioconcentrated up to four orders of magnitude (ANZG, 2018) and compared to other trace metals its toxicity is low (ANZG, 2018). Dissolved manganese was recorded above LOR at all monitoring locations for almost all sampling rounds (**Table 16**)

Figure 19 Monitoring Results: Dissolved Manganese

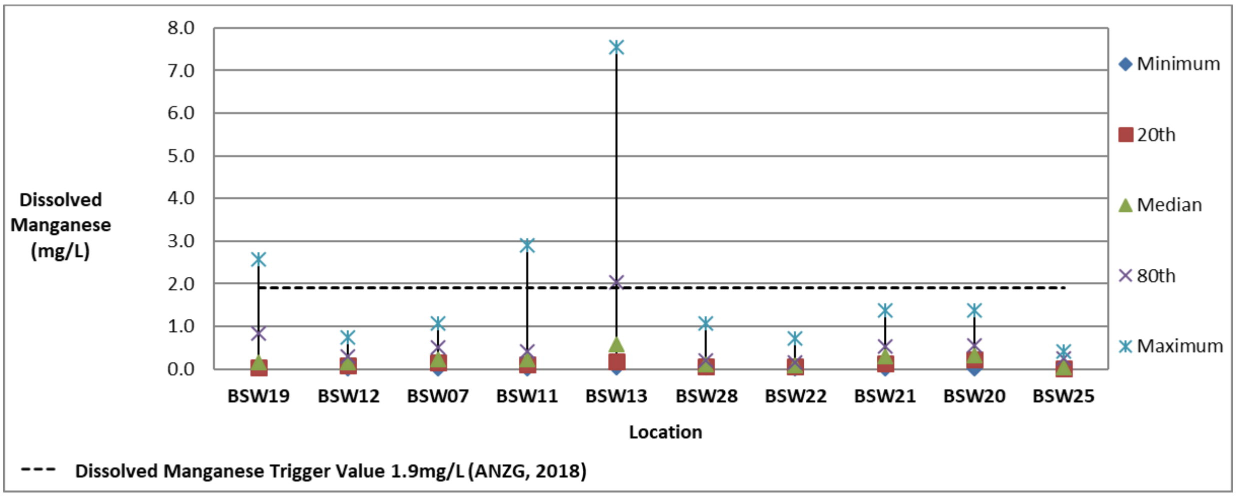


Table 16
Sample Population and Samples Below LOR: Dissolved Manganese

Location	BSW19	BSW12	BSW07	BSW11	BSW13	BSW28	BSW22	BSW21	BSW20	BSW25
Sample population	30	51	54	46	50	29	45	52	45	25
Above LOR	30	50	53	46	50	29	44	51	44	25
Below LOR	0	1	1	0	0	0	1	1	1	0
% Below LOR	0%	2%	2%	0%	0%	0%	2%	2%	2%	0%

However, it is noted that with the exception of the maximum values recorded at the monitoring locations BSW 19, BSW 13 and BSW 11, all of which are situated on Hawkins Creek, the results for all monitoring locations were all below the trigger value (**Figure 19**).

Of those three locations (BSW 19, BSW 13 and BSW 11) that recorded maximum manganese concentrations above the trigger value, these values were recorded during different sampling rounds (20 January 2017, 19 November 2014 and 15 May 2013 respectively) which suggests that there is temporal and spatial variation in manganese concentrations in Hawkins Creek. It is notable that the sampling event that recorded the highest manganese concentration, 3.0 mg/L (BSW 13) did not record elevated manganese concentrations at the downstream monitoring location (BSW 11, 0.23mg/L).

Nickel

With the exception of BSW 25, all monitoring locations returned sufficient sample populations above LOR to allow for statistical analysis (**Table 17**, **Figure 20**). Review of the analyses for total alkalinity (as $CaCO_3$) and adjustment for complexation of nickel with carbonate ions, in accordance with the algorithms presented in ANZG, indicate that the maximum recorded nickel concentration for BSW 12 (HMTV 0.028mg/L, maxima 0.043mg/L) is above the adjusted trigger value whilst all other maxima were below their respective modified trigger values. This notwithstanding, the median nickel concentrations at all monitoring locations are below the non-adjusted trigger value (0.011mg/L) and display a relatively narrow range (0.001mg/L to 0.002mg/L).

Figure 20 Monitoring Results: Dissolved Nickel

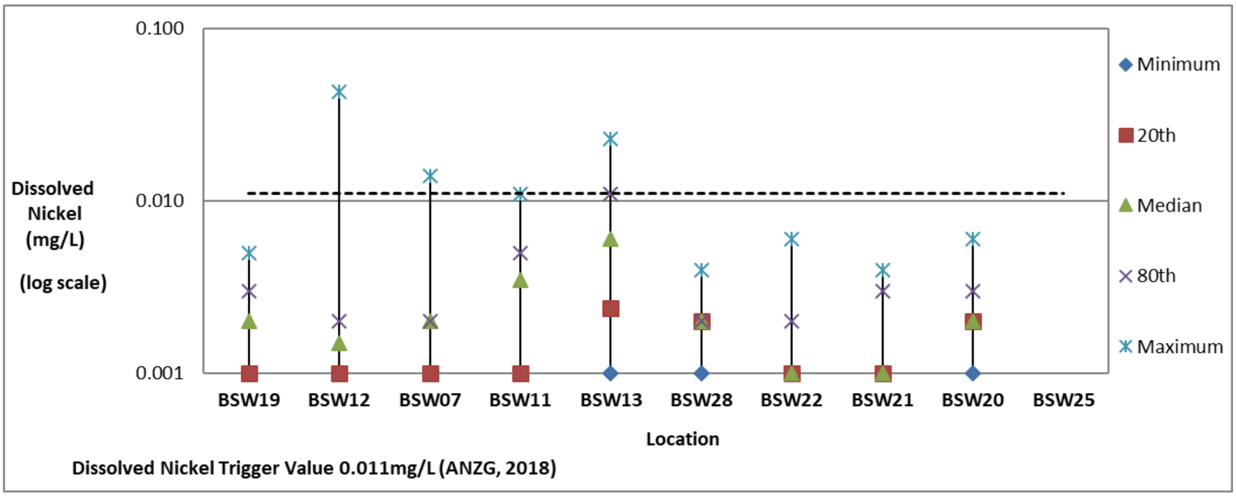


Table 17
Sample Population and Samples Below LOR: Dissolved Nickel

Location	BSW19	BSW12	BSW07	BSW11	BSW13	BSW28	BSW22	BSW21	BSW20	BSW25
Sample population	30	51	54	46	50	29	45	52	45	25
Above LOR	21	24	18	36	46	29	17	31	44	2
Below LOR	9	27	36	10	4	0	28	21	1	23
% Below LOR	30%	53%	67%	22%	8%	0%	62%	40%	2%	92%

The instances of maximum dissolved nickel concentrations were not recorded during the same sampling round however, despite this temporal variation, the spatial distribution of these results is restricted to Hawkins Creek.

Zinc

Zinc is an essential trace element for organisms and found in most natural waters in low concentrations (ANZG, 2018).

With the exception of BSW 28, all monitoring locations returned sufficient sample populations above LOR to allow for statistical analysis (**Table 18**, **Figure 21**). Review of **Figure 21** identifies that the median dissolved zinc concentration in all Hawkins Creek monitoring locations exceed the trigger value whilst only one monitoring location in Lawsons Creek (BSW 20) has a median above the trigger value. However, similar to copper, cadmium and nickel, zinc toxicity is hardness dependent, with toxicity decreasing with increasing hardness and alkalinity. Calculation of hardness modified trigger values for each monitoring location (**Figure 22**) identifies that once hardness is accounted for, the median dissolved concentrations at all monitoring locations, with the exception of BSW 19, are below the adjusted trigger values.

Figure 21 Monitoring Results: Dissolved Zinc

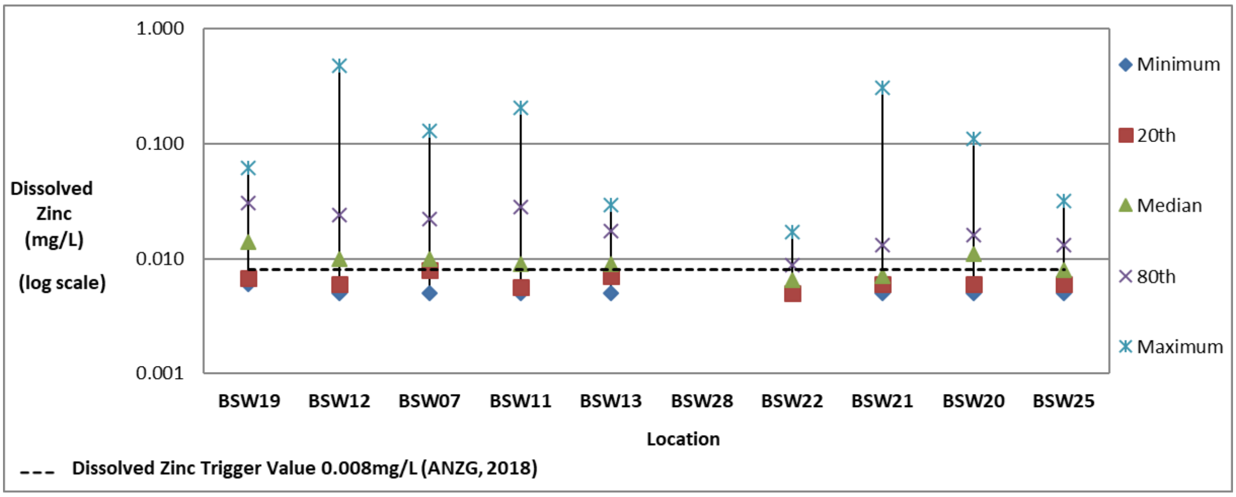


Figure 22 Monitoring Results: Dissolved Zinc (hardness modified trigger values)

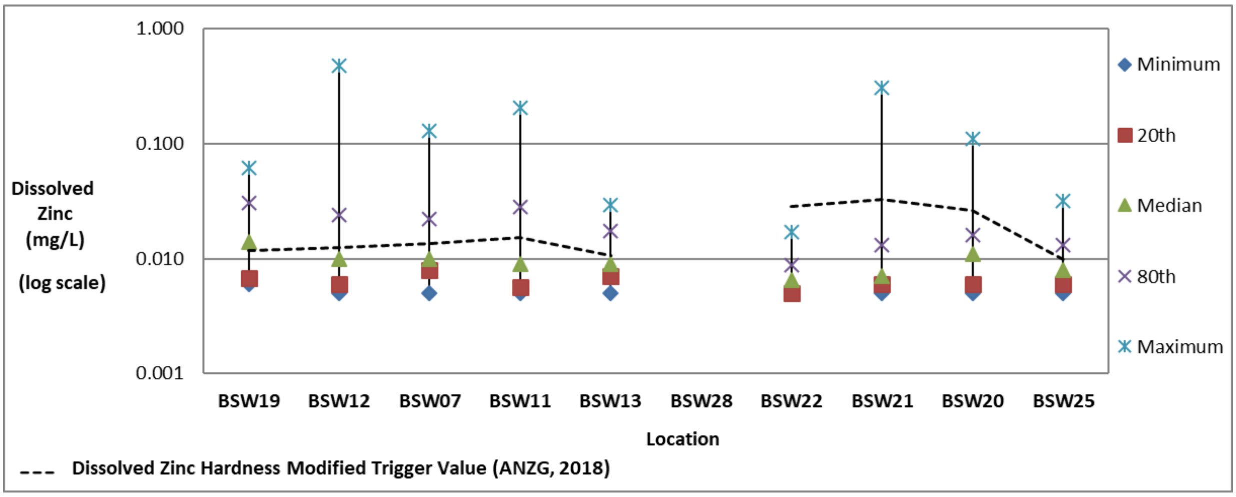


Table 18
Sample Population and Samples Below LOR: Dissolved Zinc

Location	BSW19	BSW12	BSW07	BSW11	BSW13	BSW28	BSW22	BSW21	BSW20	BSW25
Sample population	30	51	54	46	50	29	45	52	45	25
Above LOR	13	24	23	17	29	5	12	15	11	11
Below LOR	17	27	31	29	21	24	33	37	34	14
% Below LOR	57%	53%	57%	63%	42%	83%	73%	71%	76%	56%

2.5.3 Stream Sediments

The principal rationale for the leachate analyses of the collected stream sediment samples was to compare the results with the results of leachate analysis of NAF waste rock material. This was to assess the su5itability of Bowdens Silver's proposed water management system whereby runoff collected from certain catchments of the Mine Site which contained landforms and stockpiles comprised of NAF waste rock material could potentially be released into downstream watercourses, provided the collected runoff met criteria identified in an environmental protection licence for the Project. **Table 19** presents the results of the leachate analyses together with the default guideline water quality trigger values for the receiving watercourses as established by either NSW (pH and electrical conductivity) or Commonwealth (all others) regulatory authorities.

Table 19
Leachate Analyses of Selected Stream Sediment Samples

Material Analysed			**Stream Sediment**			
Sample Ref			**BSW11**	**BSW19**	**BSW20**	**BSW28**
Location#			**Hawkins Ck (upstream of Mine Site)**	**Hawkins Ck (downstream of Mine Site)**	**Lawsons Ck (upstream of Hawkins Creek)**	**Lawsons Ck (downstream of Lue)**
Parameter (µg/L)	**Unit**	**Default Trigger Value**				
pH	pH unit	6.5-8.0	6.5	5.7	7.3	7.2
Electrical conductivity	µS/cm	30-350	45	92	218	79
Aluminium	µg/L	55	310	130	40	80
Arsenic		13	2	5	2	7
Cadmium		0.2	<0.0001	0.2	<0.0001	<0.0001
Chromium		ID	<0.001	<0.001	12	<0.001
Cobalt		ID	2	6	<0.001	<0.001
Copper		1.4	<0.001	2	1	3
Iron		ID	530	50	700	60
Lead		3.4	<0.001	<0.001	<0.001	<0.001
Manganese		1900	392	158	329	<0.001
Nickel		11	1	4	2	<0.001
Zinc		8	109	431	49	55

ID = Insufficient Data # See Figure 5

3. NAF WASTE ROCK RUNOFF QUALITY

3.1 INTRODUCTION

The results of the testing program for NAF waste rock (WZ1, PZ1 and PZ2) undertaken by GCA (2019) indicate that these materials would be suitable for use in the construction, cover and rehabilitation activities over the Project life. As NAF waste rock would be utilised for the progressive development/construction of the southern barrier, WRE and TSF, consideration of runoff from these structures is considered important in the assessment of water quality downstream of the Mine Site both during and beyond the Project life. The WRE and TSF would be retained in the final landform whilst the NAF waste rock material stored in the southern barrier would be removed and used for rehabilitation of the Mine Site.

As runoff from sections of the southern barrier, WRE and TSF would enter the tributaries of Lawsons Creek during their construction and progressive development and prior to the establishment of cover vegetation (where required), appropriate measures for the capture of potentially sediment-laden runoff would be implemented. Once this runoff has been treated (i.e. after the removal/settlement of suspended sediment) to meet the relevant limit conditions of the Mine's environment protection licence, it would be discharged to assist maintaining flows in receiving watercourses.

Once extracted during mining operations and placed as part of construction, cover and rehabilitation activities, the NAF waste rock material would be exposed to atmospheric conditions and subjected to weathering processes including rainfall that could generate runoff. In order to provide an indication of the likely runoff quality, reliance has been placed upon the results of the leaching tests.

3.2 LEACHATE ANALYSES OF WEATHER NAF WASTE ROCK

Table 20 presents the results of the final round of kinetic testing and leachate analyses (i.e. representative of runoff from weathered NAF waste rock material) drawn from an analysis of the data assembled by GCA (2019). It should be noted that the results presented do not consider mixing and dilution with rainfall or runoff generated on undisturbed catchments and are therefore conservative with respect to the constituent chemistry being presented.

3.3 DISCUSSION

3.3.1 Water Quality

With regard to nutrients and electrical conductivity, the individual results of the water quality monitoring program at the Bowdens Silver Project and statistical analyses of the sample population indicate that there are influences upon water quality as a result of the agricultural activities in the contributing catchments. These influences may either be direct, as the result of runoff from pastoral lands, or indirectly as a consequence of alterations to the prevailing hydrologic regime which have subsequently influenced the geomorphic function of the watercourses.

Table 20
Results of Final Leachate Analysis of Weathered NAF Waste Rock Material

Sample ID (GCA10)		**651**	**663**	**668**	**674**	**678**	**687**	**682**
Total-S (%)		<0.01	<0.01	<0.01	0.2	0.1	0.1	0.1
Depth (m)		4.5	12.6	25.5	27.3	22.9	22.5	37.7
Class		WZ1	WZ1	PZ1	PZ2	PZ2	PZ2	PZ2
Weathering Period (weeks)		8	10	10	10	10	8	10
Parameter	**Unit**							
pH	pH	6.2	6.3	5.6	5.7	5.1	7.8	7.3
Electrical conductivity	µS/cm	49	60	68	93	150	140	64
Major ions								
Na	mg/L	8.3	0.7	1	2.1	1	13	3.5
K		0.4	8.2	10	11	12	8.5	8.7
Mg		0.15	1.6	1.7	3.8	6.6	4.7	5.4
Ca		1.3	4.3	1.5	2.9	11	7.5	11
SO4		10	21	23	38	72	12	26
Cl		<2	16	17	26	45	<2	<2
Dissolved metals								
Fe	µg/L	<0.01	0.07	<0.01	<0.01	<0.01	<0.01	<0.01
Al		<0.01	<0.01	<0.01	<0.01	0.02	0.02	<0.01
Mn		20	760	380	1400	5200	50	1000
Zn		20	50	70	40	190	20	10
Cd		0.04	0.3	0.5	0.04	0.71	<0.02	0.03
Pb		<0.5	<0.5	<0.5	0.6	1.1	1.3	<0.5
Co		0.2	13	6.9	11	42	0.2	2.5
As		42	0.7	0.6	0.5	0.5	8.9	0.3
Cu		<10	<10	<10	<10	<10	<10	<10
Ni		<10	20	10	10	60	<10	<10
Cr		<10	<10	<10	<10	<10	<10	<10
Hg		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sb		0.48	0.09	0.06	0.03	0.09	1.1	0.09
Bi		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Se		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
B		<10	<10	<10	<10	<10	<10	<10
Mo		0.32	<0.05	<0.05	<0.05	<0.05	5.5	<0.05
P		<100	<100	<100	<100	<100	<100	<100
Ag		0.04	<0.01	<0.01	0.09	0.01	<0.01	<0.01
Ba		0.9	15	20	9.9	8.5	63	2.8
Sr		5.9	19	11	24	32	74	76
Tl		0.02	4.7	2.2	0.87	2.6	0.12	0.16
V		<10	<10	<10	<10	<10	0.13	<10
Sn		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
U		0.011	0.25	0.095	0.12	0.15	19	0.085
Th		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

With regard to dissolved metals, where sufficient sample populations above LOR permit statistical analysis, the calculated medians indicate that concentrations for arsenic, manganese and nickel are below the default trigger values presented in ANZG (2018). Where calculated medians or individual results (in the case of cadmium and lead) exceed trigger values, adjustment of the trigger value to account for complexation with carbonate ions invariably identifies that trigger values are not exceeded. However, the one instance where an exceedances is clearly identified (i.e. BSW 19, median zinc) , indicates that this exceedance is isolated with little connection, either temporal or spatial with other monitoring locations to identify a clear source of the recorded exceedance.

3.3.2 NAF Waste Rock and Stream Sediments

As shown in **Tables 19** and **20**, leachate derived from both stream sediment and weathered NAF waste rock material generally exhibits similar characteristics although there are outliers such as:

- Hawkins Creek (upstream and downstream of the Mine Site): aluminium and zinc;
- Lawsons Creek (upstream of the confluence with Hawkins Creek): electrical conductivity;
- GCA10651: arsenic; and
- GCA10678: cadmium, manganese, nickel and zinc.

In addition to the outliers identified, the leachate analysis results for both stream sediment samples and NAF waste rock material identified exceedances of default water quality guidelines for a variety of parameters including:

- Aluminium: Hawkins and Lawsons Creeks;
- Cadmium: GCA10663 and GCA10668
- Copper: Hawkins and Lawsons Creeks;
- Zinc: all samples.

This notwithstanding and with the exception of outliers, the results of all leachate analyses of both the stream sediments and NAF waste rock are generally within a similar range, suggesting that any runoff from NAF waste rock material which would be utilised for the progressive development/construction of the southern barrier, WRE and TSF would be of similar quality to that of the runoff presently entering Hawkins and Lawsons Creeks, as shown in the results of leachate analyses.

4. REFERENCES

Australian and New Zealand Guideline (ANZG) (2018). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

Australian and New Zealand Environment Conservation Council (ANZECC) (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

Brierley. G. J., Fryirs. K., Outhet. D and Massey. C (2002). *Application of the River Styles framework as a basis for river management in New South Wales, Australia.* Applied Geography. Vol 22, 91-122.

Department of Environment and Heritage Protection (EHP) (2009). *Queensland Water Quality Guidelines, Version 3.*

Department of Environment and Heritage Protection (EHP) (2009). *Queensland Water Quality Guidelines,* Version 3.

Graeme Campbell & Associates Pty Ltd (GCA) (2020) – *Materials Characterisation Assessment*, Part 3 of the *Specialist Consultant Studies Compendium*. Prepared on behalf of Bowdens Silver Pty Limited

National Institute of Water and Atmospheric Research (NIWA) (2013). *Updating Nitrate Toxicity Effects on Freshwater Aquatic Species*

Office of Environment and Heritage (OEH) (2006). *NSW Aquatic Ecosystem Protection (Macquarie-Bogan River Water Quality Objectives).*

Strahler. A. (1952). *Dynamic Basis of Geomorphology.* Geological Society of America Bulletin, 63, 923-938.

Strahler. A. (1964). *Quantitative Geomorphology of Drainage Basins and Channel Networks.* In: Chow, V.T., Ed., Handbook of Applied Hydrology, McGraw–Hill, New York, 4-39/4-76.

Taylor. M and Stokes. R (2005). *Up the creek: What is wrong with the definition of a river in New South Wales?* Environmental and Planning Law Journal. Vol 22, 193-211.

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Attachments

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Attachment 1

Statistical Analysis

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Table A1.1
Monitoring Results Statistical Summary: Hawkins Creek

			Watercourse																				
			Location in Watercourse																				
			Sample ID	**BSW13 (Upstream)**					**BSW11 (Mid-chainage)**					**BSW07 (Mid-chainage)**					**BSW12 (Downstream)**				
				Min	**20th**	**Median**	**80th**	**Max**	**Min**	**20th**	**Median**	**80th**	**Max**	**Min**	**20th**	**Median**	**80th**	**Max**	**Min**	**20th**	**Median**	**80th**	**Max**
Parameter	**Unit**	**LOR**	**Trigger**																				
pH	pH Unit	0.01	**6.5-8.0**	6.6	6.9	7.4	7.8	9.0	6.4	7.1	7.45	7.7	8.7	6.4	6.6	6.9	7.0	8.1	6.1	7.1	7.4	7.7	8.7
Electrical Conductivity (µS/cm)	µS/cm	1	**30-350**	123	329.6	645	**819.8**	3550	105	378.4	569.5	**810.0**	1570	73.0	437.8	463.0	**525.5**	925	249	386	491	**550.0**	755
Total Suspended Solids (mg/L)	mg/L	1		0	3.0	9	99.2	2195	0	7.6	13.5	48.2	544	0.1	4	10.0	16.0	57	1	2	5	11.6	56
Bicarbonate Alkalinity as CaCO3	mg/L	1		10	46.0	83	137.8	178	10	76.2	117	159.0	253	4.0	84	100.0	114.0	213	30	72.6	90.5	129.4	199
Carbonate Alkalinity as CaCO3	mg/L	1		Below LOR	Below LOR	Below LOR	Below LOR	0	3	1.0	15	Below LOR	27	9.0	Below LOR	9.0	Below LOR	9	11	1	11.5	Below LOR	12
Hydroxide Alkalinity as CaCO3	mg/L	1		Below LOR	Below LOR	Below LOR	Below LOR	0	Below LOR	Below LOR	Below LOR	Below LOR	0	Below LOR	Below LOR	Below LOR	Below LOR	0	Below LOR	Below LOR	Below LOR	Below LOR	0
Total Alkalinity as CaCO3	mg/L	1		10	46.0	83	137.8	178	10	73.8	116	152.0	253	4.0	80	100.0	114.0	222	6	73	89.5	129.4	199
Sulphate (mg/L)	mg/L	1		14	32.0	48	135.0	735	5	26.4	46	69.2	171	4.0	33.4	41.0	47.0	113	10	27	47	64.8	102
Chloride	mg/L	1		7	28.8	86	136.0	704	8	37.6	66.5	150.4	360	12.0	45.4	52.0	69.0	165	24	44	53	67.4	118
Calcium	mg/L	1	**1000**	3	11.2	19.5	24.0	170	5	14.8	22.5	29.6	43	1.0	22.4	26.0	29.0	41	10	17	22	27.0	42
Magnesium	mg/L	1		3	11.2	19.5	26.0	136	3	11.6	18	28.4	41	1.0	13	15.0	18.0	36	8	14	17	19.4	29
Potassium	mg/L	1		2	2.0	3	4.0	25	2	3.0	5	11.2	28	3.0	4	4.0	5.0	8	2	4	5	7	14
Sodium	mg/L	1		12	38.6	86	100.6	365	9	45.0	65	104.0	204	5.0	38	44.0	54.4	118	22	37.6	46	60.4	88
Dissolved Arsenic (mg/L)	mg/L	1	**0.013**	0.001	0.0	0.001	0.003	0.004	0.001	0.0	0.002	0.002	0.003	0.0	0.001	0.0	0.0	0.002	0.001	0.001	0.001	0.001	0.002
Dissolved Cadmium (mg/L)	mg/L	0.1	**0.0002**	0	0.0	Below LOR	Below LOR	0.0000	0.0001	0.0	0.0001	0.0002	0.0002	0.0	0.00014	0.0	0.0	0.0002	0.0002	0.00014	0.0002	0.0002	0.0002
Dissolved Cobalt (mg/L)	mg/L	1	**ID**	0.001	0.0	0.002	0.005	0.017	0.001	0.0	0.002	0.003	0.004	0.0	0.001	0.0	0.0	0.006	0.001	0.001	0.002	0.002	0.002
Dissolved Copper (mg/L)	mg/L	1	**0.0014**	0.001	0.0	0.002	0.004	0.009	0.001	0.0	0.002	0.005	0.019	0.0	0.001	0.0	0.0	0.005	0.001	0.001	0.001	0.0020	0.02
Dissolved Iron (mg/L)	mg/L	50	**ID**	0.06	0.1	0.19	0.528	1.230	0.06	0.1	0.225	0.520	1.15	0.1	0.14	0.2	0.5	2.93	0.05	0.08	0.15	0.284	0.84
Dissolved Lead (mg/L)	mg/L	1	**0.0034**	0.001	0.0	0.0015	0.002	0.002	0.007	0.0034	0.007	0.007	0.007	Below LOR	Below LOR	Below LOR	Below LOR	0	Below LOR	Below LOR	Below LOR	Below LOR	0
Dissolved Manganese (mg/L)	mg/L	1	**1.9**	0.042	0.1	0.293	0.838	3.070	0.005	0.1	0.2185	0.419	2.91	0.0	0.1378	0.2	0.4	1.08	0.008	0.0704	0.1385	0.286	0.751
Dissolved Nickel (mg/L)	mg/L	1	**0.011**	0.001	0.0	0.004	0.006	0.011	0.001	0.0	0.0035	0.005	0.011	0.0	0.001	0.0	0.0	0.014	0.001	0.001	0.002	0.002	0.043
Dissolved Zinc (mg/L)	mg/L	5	**0.008**	0.006	0.0	0.008	0.017	0.029	0.005	0.0	0.009	0.028	0.206	0.0	0.008	0.0	0.0	0.13	0.005	0.006	0.01	0.024	0.478
Ammonia (mg/L)	mg/L	0.01	**0.9**	0.02	0.0	0.03	0.1	0.75	0.02	0.0	0.06	0.1	1.87	0.0	0.03	0.0	0.1	0.12	0.01	0.02	0.03	0.0	0.05
Nitrite as N	mg/L	0.01	**30**	0.03	0.0	0.035	0.0	0.04	0.02	0.0	0.045	0.1	0.06	0.0	0.01	0.0	0.0	0.05	Below LOR	Below LOR	Below LOR	Below LOR	0
Nitrate (mg/L)	mg/L	0.01	**0.4**	0.02	0.0	0.05	0.1	0.4	0.01	0.0	0.045	0.3	2.26	0.0	0.03	0.1	0.2	0.74	0.01	0.012	0.03	0.1	0.15
Nitrite + Nitrate as N	mg/L	0.01	**430**	0.02	0.0	0.05	0.1	0.46	0.01	0.0	0.06	0.3	2.32	0.0	0.03	0.1	0.2	0.74	0.01	0.012	0.03	0.1	0.15
Total Kjeldahl Nitrogen (as N)	mg/L	0.1		0.2	0.4	0.8	1.4	10.3	0.2	0.3	0.95	2.1	11.6	0.1	0.2	0.4	0.9	4.39	0.1	0.2	0.4	0.6	5.49
Total Nitrogen (mg/L)	mg/L	0.1	**0.25**	0.2	0.4	0.7	**1.2**	10.7	0.2	0.5	1	**2.2**	11.6	0.1	0.3	0.6	**0.9**	3.8	0.1	0.2	0.4	**0.6**	1.4
Total Phosphorus (mg/L)	mg/L	0.01	**0.02**	0.01	0.0	0.045	**0.2**	2.62	0.01	0.0	0.07	**0.2**	2.2	0.0	0.02	0.0	**0.1**	1.85	0.01	0.012	0.03	**0.1**	0.7
Ionic Balance	%	0.01		0.13	0.6	1.52	3.6	25.90	0.15	0.9	1.74	3.8	30.8	0.2	0.724	1.4	3.0	7.74	0.24	0.938	1.94	4.13	6.16
Total Anions	meq/L	0.01		1	3.0	6.805	14.5	163.00	2.36	3.6	5.355	8.8	199	2.5	4.064	4.4	4.7	98	2.20	3.926	4.515	5.284	125
Total Cations	meq/L	0.01		1.8	4.1	6.82	12.2	35.60	2.58	4.2	5.54	8.6	14.8	2.8	4.084	4.4	4.8	5.7	2.43	3.728	4.59	5.44	7.84

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Table A1.2
Monitoring Results Statistical Summary: Lawsons Creek

Watercourse / Location in Watercourse / Sample ID				BSW19 (Downstream)					BSW20 (Upstream)				
Parameter	**Unit**	**LOR**	**Trigger**	**Min**	**20th**	**Median**	**80th**	**Max**	**Min**	**20th**	**Median**	**80th**	**Max**
pH	pH Unit	0.01	**6.5-8.0**	6.2	6.66	7.2	7.4	8.0	7	7.6	7.9	**8.4**	8.8
Electrical Conductivity (µS/cm)	µS/cm	1	**30-350**	254	405.6	498	**567.8**	939.0	300	832	1120	**1285.0**	2050
Total Suspended Solids (mg/L)	mg/L	1		0	3.6	12	45.4	74.0	0	9.8	16.5	48.2	103
Bicarbonate Alkalinity as CaCO3	mg/L	1		23	58.6	87	102.0	181.0	59	133.6	223	291.8	351
Carbonate Alkalinity as CaCO3	mg/L	1		Below LOR	Below LOR	Below LOR	Below LOR	0.0	4	4	29	40.0	40
Hydroxide Alkalinity as CaCO3	mg/L	1		Below LOR	Below LOR	Below LOR	Below LOR	0.0	Below LOR	Below LOR	Below LOR	Below LOR	0
Total Alkalinity as CaCO3	mg/L	1		13	40.2	85.5	100.0	181.0	12	127.6	223	307.8	358
Sulphate (mg/L)	mg/L	1		8	32	43.5	69.4	261.0	34	81	136	211.2	274
Chloride	mg/L	1		30	44.8	58.5	80.0	123.0	28	102.6	142	194.2	376
Calcium	mg/L	1	**1000**	10	14.6	19.5	22.8	52.0	13	33.8	48	58.6	75.0
Magnesium	mg/L	1		8	13	16	20.0	34.0	12	38	48	60.6	93
Potassium	mg/L	1		3	4	5	7.8	11.0	3	4.8	5	8.0	15
Sodium	mg/L	1		26	40.8	51	62.0	73.0	28	74	105	141.8	277
Dissolved Arsenic (mg/L)	mg/L	1	**0.013**	0.001	0.001	0.0015	0.003	0.0	0.001	0.001	0.002	0.004	0.006
Dissolved Cadmium (mg/L)	mg/L	0.1	**0.0002**	Below LOR	Below LOR	Below LOR	Below LOR	0.0	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Cobalt (mg/L)	mg/L	1	**ID**	0.001	0.002	0.004	0.006	0.0	0.001	0.001	0.0015	0.002	0.002
Dissolved Copper (mg/L)	mg/L	1	**0.0014**	0.001	0.001	0.001	0.003	0.0	0.001	0.0012	0.002	0.003	0.006
Dissolved Iron (mg/L)	mg/L	50	**ID**	0.09	0.2	0.365	0.800	4.9	0.05	0.06	0.08	0.190	0.67
Dissolved Lead (mg/L)	mg/L	1	**0.0034**	Below LOR	Below LOR	Below LOR	Below LOR	0.0	0.001	0.001	0.003	0.004	0.005
Dissolved Manganese (mg/L)	mg/L	1	**1.9**	0.001	0.038	0.146	0.842	2.6	0.013	0.213	0.3135	0.513	1.38
Dissolved Nickel (mg/L)	mg/L	1	**0.011**	0.001	0.001	0.002	0.003	0.0	0.001	0.002	0.002	0.003	0.006
Dissolved Zinc (mg/L)	mg/L	5	**0.008**	0.006	0.0068	0.014	0.030	0.1	0.005	0.006	0.011	0.016	0.109
Ammonia (mg/L)	mg/L	0.01	**0.9**	0.01	0.01	0.025	0.1	0.2	0.01	0.01	0.02	0.0	0.09
Nitrite as N	mg/L	0.01	**30**	Below LOR	Below LOR	Below LOR	Below LOR	0.0	0.01	0.01	0.01	0.0	0.01
Nitrate (mg/L)	mg/L	0.01	**0.4**	0.01	0.02	0.03	0.0	0.1	0.01	0.01	0.03	0.0	0.07
Nitrite + Nitrate as N	mg/L	0.01	**430**	0.01	0.02	0.03	0.0	0.1	0.01	0.014	0.03	0.0	0.07
Total Kjeldahl Nitrogen (as N)	mg/L	0.1		0.1	0.3	0.55	1.3	7.2	0.4	0.6	0.9	1.6	13.7
Total Nitrogen (mg/L)	mg/L	0.1	**0.25**	0.1	0.3	0.6	**1.3**	2.5	0.4	0.6	0.9	**1.6**	3
Total Phosphorus (mg/L)	mg/L	0.01	**0.02**	0.01	0.02	0.065	**0.2**	1.5	0.01	0.03	0.06	**0.1**	1.6
Ionic Balance	%	0.01		0.07	0.446	2.075	4.2	6.3	0.06	0.902	2.64	4.8	16.5
Total Anions	meq/L	0.01		2.30	3.692	4.41	5.5	119.0	2.68	8.774	12.1	13.8	180
Total Cations	meq/L	0.01		2.36	3.662	4.49	5.6	8.4	2.93	9.2	11.15	13.2	23

Parameter	BSW21 (Downstream)					BSW22 (Downstream)				
	Min	**20th**	**Median**	**80th**	**Max**	**Min**	**20th**	**Median**	**80th**	**Max**
pH	7.1	7.3	7.6	7.9	8	7.3	7.5	7.8	8.0	8.5
Electrical Conductivity (µS/cm)	510	804	1080	**1400.0**	1890	300	709.2	945	**1040.0**	1800
Total Suspended Solids (mg/L)	0	3	11	14.8	190	0	3	6	14.0	94
Bicarbonate Alkalinity as CaCO3	72	141.8	204	390	503	59	137.2	214.5	291.6	339
Carbonate Alkalinity as CaCO3	Below LOR	Below LOR	Below LOR	Below LOR	0	18	Below LOR	18	Below LOR	18
Hydroxide Alkalinity as CaCO3	Below LOR	Below LOR	Below LOR	Below LOR	0	Below LOR	Below LOR	Below LOR	Below LOR	0
Total Alkalinity as CaCO3	16	96.4	193.5	361	446	59	136	205	280.4	339
Sulphate (mg/L)	75	99.4	133	233.2	314	15	47.4	99	160.4	359
Chloride	38	87.8	129	179.6	236	28	56	94	126.0	315
Calcium	20	35	51	85.8	104.0	13	36	54	62.0	87.0
Magnesium	23	34.8	46	56.8	70	12	29.6	40	46.0	65
Potassium	2	3	5	6	7	3	3	4	5.0	6
Sodium	48	77	113.5	175	228	28	59	85	103.0	217
Dissolved Arsenic (mg/L)	0.001	0.001	0.002	0.0	0.003	0.001	0.001	0.0015	0.0020	0.004
Dissolved Cadmium (mg/L)	0.001	0.001	0.001	0.001	0.001	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Cobalt (mg/L)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0010	0.001
Dissolved Copper (mg/L)	0.001	0.001	0.001	0.0	0.003	0.001	0.001	0.002	0.0020	0.005
Dissolved Iron (mg/L)	0.06	0.06	0.085	0.162	0.36	0.05	0.07	0.085	0.2600	0.55
Dissolved Lead (mg/L)	Below LOR	Below LOR	Below LOR	Below LOR	0	Below LOR	Below LOR	Below LOR	Below LOR	0
Dissolved Manganese (mg/L)	0.053	0.1186	0.262	0.5	0.653	0.033	0.053	0.087	0.1646	0.711
Dissolved Nickel (mg/L)	0.001	0.001	0.001	0.0	0.004	0.001	0.001	0.001	0.0024	0.006
Dissolved Zinc (mg/L)	0.005	0.0056	0.007	0.0	0.304	0.005	0.005	0.0065	0.009	0.017
Ammonia (mg/L)	0.01	0.02	0.03	0.0	0.06	0.01	0.01	0.02	0.0	0.06
Nitrite as N	Below LOR	Below LOR	Below LOR	Below LOR	0	0.03	0.018	0.03	0.0	0.03
Nitrate (mg/L)	0.01	0.016	0.05	0.1	0.15	0.01	0.018	0.03	0.1	0.45
Nitrite + Nitrate as N	0.01	0.016	0.05	0.1	0.15	0.01	0.018	0.03	0.1	0.45
Total Kjeldahl Nitrogen (as N)	0.1	0.4	0.6	0.88	15.5	0.2	0.3	0.5	0.8	11.9
Total Nitrogen (mg/L)	0.1	0.4	0.65	**0.9**	1.4	0.2	0.3	0.5	**0.8**	2.1
Total Phosphorus (mg/L)	0.02	0.024	0.04	**0.1**	1.4	0.01	0.02	0.03	**0.1**	0.4
Ionic Balance	0.38	0.516	1.73	2.586	4.65	0.09	0.502	1.89	2.8	5.63
Total Anions	8.20	9.502	12.9	18.36	503	3.29	8.282	9.56	10.6	302
Total Cations	8.18	10.1	12.8	17.44	20.8	3.31	8.51	9.9	11.3	13.8

Parameter	BSW28 (Downstream)					BSW25 (Tributary-downstream)				
	Min	**20th**	**Median**	**80th**	**Max**	**Min**	**20th**	**Median**	**80th**	**Max**
pH	7.3	7.78	8	**8.1**	8.4	7.1	6.46	7.05	7.3	9.4
Electrical Conductivity (µS/cm)	379	785	1020	**1180.0**	1280	176.07	126.8	172	210.8	250
Total Suspended Solids (mg/L)	7	8	13	22.8	39	23	7	23	54.0	98
Bicarbonate Alkalinity as CaCO3	80	206.4	264	314	375	60.57	30.8	58.5	90	106
Carbonate Alkalinity as CaCO3	5	Below LOR	Below LOR	Below LOR	24	14	Below LOR	14	Below LOR	14
Hydroxide Alkalinity as CaCO3	0	Below LOR	Below LOR	Below LOR	0	Below LOR	Below LOR	Below LOR	Below LOR	0
Total Alkalinity as CaCO3	80	206.4	Below LOR	314.2	399	61.57	30.8	58.5	90	106
Sulphate (mg/L)	41	76.8	Below LOR	150.8	257	9	4.4	8.5	13	15
Chloride	32	68	Below LOR	128.2	140	10	6.4	10	13	14
Calcium	20	42.2	Below LOR	63.4	71.0	2	2	2	3.2	4.0
Magnesium	14	33	Below LOR	51	54	10	5	10	13	15
Potassium	3	3	Below LOR	6.2	9	12	7	12	15	17
Sodium	33	70.8	Below LOR	107.6	138	11	5.8	11	12	15
Dissolved Arsenic (mg/L)	0.001	0.001	0.002	0.0	0.004	0.001	0.001	0.0025	0.0	0.004
Dissolved Cadmium (mg/L)	0.0001	0.0001	0.0001	0.0	0.0001	Below LOR	Below LOR	Below LOR	Below LOR	0
Dissolved Cobalt (mg/L)	0.002	0.002	0.002	0.002	0.002	0.001	0.0012	0.002	0.0022	0.003
Dissolved Copper (mg/L)	0.001	0.001	0.002	0.0	0.002	0.001	0.0012	0.002	0.0	0.007
Dissolved Iron (mg/L)	0.05	0.06	0.07	0.216	0.53	0.18	0.24	0.535	1.86	2.85
Dissolved Lead (mg/L)	0.002	0.002	0.002	0.0	0.002	0.001	0.001	0.0015	0.0	0.002
Dissolved Manganese (mg/L)	0.027	0.055	0.088	0.1	1.06	0.018	0.018	0.0315	0.1	0.366
Dissolved Nickel (mg/L)	0.001	0.002	0.002	0.0	0.004	0.001	0.001	0.001	0.0	0.001
Dissolved Zinc (mg/L)	0.006	0.006	0.007	0.0	0.023	0.005	0.0058	0.0075	0.0	0.016
Ammonia (mg/L)	0.01	0.02	0.03	0.0	0.06	0.01	0.03	0.06	0.2	0.52
Nitrite as N	0	Below LOR	Below LOR	Below LOR	0	0.01	0.01	0.02	0.0	0.02
Nitrate (mg/L)	0.01	0.014	0.03	0.1	0.06	0.02	0.046	0.175	0.5	2.86
Nitrite + Nitrate as N	0.01	0.014	0.03	0.1	0.06	0.02	0.046	0.18	0.5	2.88
Total Kjeldahl Nitrogen (as N)	0.2	0.4	0.6	0.96	1.5	0.4	0.6	0.85	1.84	2.6
Total Nitrogen (mg/L)	0.2	0.4	0.6	**1.0**	1.5	0.6	0.8	1.15	**2.4**	3.8
Total Phosphorus (mg/L)	0.01	0.02	0.05	**0.1**	0.37	0.01	0.016	0.045	**0.1**	0.18
Ionic Balance	0.32	1.098	3.13	4.49	8.06	0.31	0.41	1.74	2.842	3.37
Total Anions	3.35	8.108	10.3	13.1	14.6	0.98	1.03	1.57	2.02	2.51
Total Cations	3.66	8.284	10.5	12.24	13.6	1.04	1.292	1.75	2.26	2.43

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Attachment 2

Analytical Results by Monitoring Location

(Total No. of pages including blank pages = 32)

Note: This Attachment is only available on the digital version of this document

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Table A2.1
Monitoring Results: Hawkins Creek (Upstream) BSW 13

Sampling Date

Parameter	Unit	LOR	Mean	28/06/12	18/07/12	16/08/12	13/09/12	18/10/12	21/11/12	20/12/12	19/02/13	20/03/13	15/04/13	15/05/13	20/06/13	20/08/13	19/11/13	20/02/14	19/05/14	19/08/14	19/11/14	04/02/15	01/05/15	07/08/15	03/02/16
pH Value	pH Unit	0.01	**7.4**	7.8	7.8	7.8	7.9	7.7	8.5	7.4	7.9	7.3	7.4	7.3	7.1	7.5	7.4	7	6.8	7	7.8	7.3	6.6	6.9	9
Electrical Conductivity @ 25°C	µS/cm	1	**768**	690	535	635	750	765	525	840	725	610	655	605	825	835	664	209	572	1210	1380	356	259	312	211
Suspended Solids (SS)	mg/L	1	**125**							<5	4	6	5	4	13	4	0.07	376	9	13	71	2195	140	190	175
Bicarbonate Alkalinity as CaCO3	mg/L	1	**92**								142	143	133	173	93	127	163	12	57	78	178	75	30	31	83
Carbonate Alkalinity as CaCO3	mg/L	1									<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1									<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**91**								142	143	133	173	93	127	146	12	57	78	178	75	30	31	83
Sulfate as SO4 - Turbidimetric	mg/L	1	**103**	48	41	37	39	35	34	72	66	43	38	32	107	97	48	50	74	192	234	98	55	14	14
Chloride	mg/L	1	**119**	110	87	115	145	122	53	136	101	85	91	68	122	133	82	23	84	213	230	28	23	7	12
Calcium	mg/L	1	**26**	17	14	16	21	20	17	24	18	19	20	20	20	22	14	6	13	36	47	24	10	10	7
Magnesium	mg/L	1	**25**	22	18	20	25	21	17	22	21	20	19	18	26	26	15	5	13	35	39	20	9	10	7
Potassium	mg/L	1	**4**	2	3	2	2	2	3	3	3	2	4	4	4	4	2	4	2	7	11	25	6	4	2
Sodium	mg/L	1	**95**	79	64	81	99	96	69	<0.001	98	85	92	78	98	107	98	29	86	157	193	89	31	38	19
Arsenic	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.004	0.001	<0.001	<0.001
Cadmium	mg/L	0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.004**								0.002	0.003	0.001	0.006	<0.001	0.002	<0.001	0.002	<0.001	0.002	0.001	0.003	0.001	0.001	<0.001
Copper	mg/L	0.001	**0.003**	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	0.004	0.005	0.002	0.001	0.003	0.009	0.007	0.002	0.002
Iron	mg/L	0.05	**0.310**	0.08	0.25	0.17	0.22	0.13	0.1	<0.05	<0.05	0.11	0.11	0.6	0.27	0.1	<0.05	0.08	<0.05	0.35	<0.05	0.1	1.23	0.09	0.06
Lead	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	<0.001	<0.001
Manganese	mg/L	0.001	**0.561**	0.068	0.054	0.046	0.214	0.263	0.065	0.216	0.455	0.795	0.348	3.07	0.227	0.668	0.197	0.59	0.042	0.903	0.581	0.286	0.291	0.546	0.113
Nickel	mg/L	0.001	**0.005**	<0.001	<0.001	0.002	0.002	0.003	0.004	0.001	0.004	0.006	0.005	0.006	0.002	0.002	0.006	0.005	0.002	0.004	0.006	0.01	0.008	0.004	0.003
Zinc	mg/L	0.005	**0.011**	<0.005	<0.005	0.008	<0.005	0.006	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.008	0.013	0.006	0.017	0.018	0.029	<0.005	<0.005
Ammonia as N	mg/L	0.01	**0.12**								0.02	<0.01	<0.01	<0.01	0.03	0.04	0.02	0.75	0.04	<0.01	0.18	0.66	0.02	<0.01	0.02
Nitrite as N	mg/L	0.01	**0.04**								<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	**0.10**								0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.42	<0.01	<0.01	0.05	0.36	<0.01	0.02	0.18
Nitrite + Nitrate as N	mg/L	0.01	**0.11**								0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.46	<0.01	<0.01	0.05	0.39	<0.01	0.02	0.18
Total Kjeldahl Nitrogen as N	mg/L	0.1	**1.4**								0.6	1	0.4	0.5	0.6	1.1	6.25	3.3	0.6	1.1	1.9	10.3	1.4	0.2	0.8
Total Nitrogen as N	mg/L	0.1	**1.3**								0.7	1	0.4	0.5	0.6	1.1	0.6	3.8	0.6	1.1	2	10.7	1.4	0.2	1
Total Phosphorus as P	mg/L	0.01	**0.25**								0.02	0.44	0.02	0.04	0.02	0.04	0.6	1.01	0.05	0.08	0.07	2.62	0.29	0.03	0.1
Ionic Balance	%	0.01	**3.13**								0.7	1.52	0.81	0.58	0.18	1.95	2.55		1.39	0.51	2.36	25.9			
Total Anions	meq/L	0.01	**14.95**								7.06	6.15	6.55	6.04	7.53	8.31	163	1.93	5.34	11.6	14.9	4.33	2.39		2.29
Total Cations	meq/L	0.01	**9.21**								6.97	6.34	6.67	5.97	7.5	7.99	6.57	2.07	5.49	11.7	14.2	7.35	2.74		1.8

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Table A2.1 (Cont'd)
Monitoring Results: Hawkins Creek (Upstream) BSW 13

				Sampling Date																											
Parameter	**Unit**	**LOR**	**Mean**	**11/05/16**	**31/08/16**	**26/09/16**	**24/10/16**	**21/11/16**	**12/12/16**	**19/01/17**	**16/02/17**	**14/03/17**	**28/04/17**	**17/05/17**	**14/06/17**	**13/07/17**	**22/08/17**	**19/09/17**	**17/10/17**	**14/11/17**	**12/12/17**	**16/01/18**	**15/02/18**	**14/03/18**	**17/04/18**	**18/05/18**	**18/06/18**	**16/08/18**	**20/09/18**	**22/10/18**	**14/11/18**
pH Value	pH Unit	0.01	**7.4**	6.9	7.4	7.4	7.5	7.1	7.3	7.4	7.8	8	7	6.6	6.8	6.9	6.8	7.0	7.2	7.70	7.0	7.2	7.4	6.8	7.0	6.5	6.7	6.6	6.8	7.3	7.3
Electrical Conductivity @ 25°C	µS/cm	1	**768**	123	1230	249	420	422	450	565	2600	3550	818	811	714	702	689	681	766	413	801	1080	1640	865	972	950	887	729	702	663	761
Suspended Solids (SS)	mg/L	1	**125**	72	5	6	7	3	3	12	22	14	2	3	18	8	16	6	11	59	4	7	20	3	3	2	12	13	5	2	16
Bicarbonate Alkalinity as CaCO3	mg/L	1	**92**	10	126	46	80	89	107	135	109	80	67	46	61	62	64	69	92	106	87	32	46	23	48	38	87	55	58	58	66
Carbonate Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**91**	10	126	46	80	89	107	135	109	80	67	46	61	62	64	69	92	106	87	32	46	23	48	38	87	55	58	58	66
Sulfate as SO4 - Turbidimetric	mg/L	1	**103**	21	135	21	22	32	41	43	574	735	143	151	115	104	113	109	118	36	122	240	332	176	186	213	158	153	125	114	142
Chloride	mg/L	1	**119**	13	238	30	59	48	51	61	449	704	126	116	84	86	78	78	107	34	133	188	278	148	168	163	148	114	106	104	124
Calcium	mg/L	1	**26**	3	34	10	13	18	20	23	120	170	24	24	19	16	21	20	22	9	24	36	64	26	29	30	27	20	19	17	23
Magnesium	mg/L	1	**25**	3	40	8	14	15	18	19	93	136	22	24	19	18	14	22	20	10	22	32	51	22	25	27	24	19	14	14	19
Potassium	mg/L	1	**4**	7	6	4	3	3	3	3	4	4	3	2	2	2	6	1	4	17	3	2	4	3	2	2	2	1	<1	1	1
Sodium	mg/L	1	**95**	12	158	27	50	41	44	60	315	365	98	98	89	99	63	81	98	44	94	132	203	100	110	117	103	99	88	88	107
Arsenic	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.004**	<0.001	0.003	<0.001	0.001	<0.001	<0.001	<0.001	0.001	0.002	0.009	0.017	0.01	0.011	<0.001	0.013	0.016	0.001	0.014	0.007	0.002	0.011	0.016	0.034	0.048	0.025	0.017	0.008	0.003
Copper	mg/L	0.001	**0.003**	0.003	<0.001	0.002	0.002	<0.001	0.002	<0.001	0.003	0.002	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.001	<0.001	0.003	<0.001	0.002	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	**0.310**	0.57	0.64	0.56	1.05	0.4	0.19	0.22	<0.05	<0.05	0.19	0.17	0.32	0.33	<0.05	0.40	0.42	0.32	0.66	<0.05	<0.05	0.11	0.08	0.21	0.50	0.05	<0.05	<0.05	<0.05
Lead	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.561**	0.061	1.01	0.05	0.275	0.563	0.295	0.171	0.458	0.95	1.15	2.29	1.76	1.61	0.049	1.96	3.52	0.620	2.65	1.79	1.46	1.48	2.70	4.40	7.56	3.06	2.46	2.26	1.65
Nickel	mg/L	0.001	**0.005**	0.004	0.003	0.003	0.003	0.002	<0.001	<0.001	0.006	0.008	0.009	0.011	0.008	0.006	0.002	0.011	0.012	0.002	0.011	0.014	0.008	0.013	0.019	0.023	0.022	0.016	0.014	0.009	0.008
Zinc	mg/L	0.005	**0.011**	0.009	<0.005	0.02	0.006	0.016	0.007	<0.005	<0.005	0.006	0.007	0.011	0.007	0.007	<0.005	<0.005	0.009	<0.005	0.021	0.007	0.005	0.012	0.012	0.023	0.018	0.016	0.010	<0.005	<0.005
Ammonia as N	mg/L	0.01	**0.12**	<0.01	0.03	<0.01	0.1	<0.01	<0.01	<0.01	0.02	0.03	0.03	0.02	0.04	<0.01	<0.01	<0.01	0.01	0.10	0.01	<0.01	0.04	<0.01	0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01
Nitrite as N	mg/L	0.01	**0.04**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.02
Nitrate as N	mg/L	0.01	**0.10**	<0.01	0.03	0.02	0.03	0.06	<0.01	0.08	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.02	0.03	0.03	<0.01	0.02	<0.01	0.02	<0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	**0.11**	<0.01	0.03	0.02	0.03	0.06	<0.01	0.08	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.02	0.03	0.03	<0.01	0.03	<0.01	0.02	<0.01	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	**1.4**	0.7	1.1	0.8	0.8	0.5	0.2	0.5	1.6	1.2	0.4	0.2	0.4	0.3	0.3	0.3	0.4	1.6	0.6	0.3	0.9	0.1	0.3	0.2	0.3	0.2	0.3	0.2	0.4
Total Nitrogen as N	mg/L	0.1	**1.3**	0.7	1.1	0.8	0.8	0.6	0.2	0.6	1.6	1.2	0.4	0.2	0.4	0.3	0.3	0.3	0.4	1.6	0.6	0.3	0.9	0.1	0.3	0.2	0.3	0.2	0.3	0.2	0.4
Total Phosphorus as P	mg/L	0.01	**0.25**	0.2	0.05	0.03	0.04	<0.01	<0.01	0.02	0.1	0.03	0.01	<0.01	0.02	0.05	0.25	0.02	0.04	0.27	0.04	<0.01	0.08	0.02	0.03	<0.01	<0.01	0.01	0.01	<0.01	0.02
Ionic Balance	%	0.01	**3.13**		0.13		4.27	5.42	5.64	0.94	1.2	1.53	3.43	1.02	3.64	6.47	6.75	4.17	1.42	2.76	5.63	3.38	2.03	4.83	6.87	5.00	7.91	4.21	6.49	4.97	2.52
Total Anions	meq/L	0.01	**14.95**	1	12	2.51	3.72	4.99	14.5	17.7	26.8	36.8	7.87	7.34	5.98	5.83	5.83	5.85	7.31	3.83	8.03	10.9	15.7	8.30	9.57	9.79	9.20	7.50	6.75	6.47	7.77
Total Cations	meq/L	0.01	**9.21**	2.8	4.05	5.56	13	18	27.4	35.6	7.35			7.49	6.43	6.64	5.09	6.36	7.11	3.62	7.17	10.2	16.3	7.53	8.34	8.86	7.85	6.89	5.93	5.85	7.39

Table A2.2
Monitoring Results: Hawkins Creek (Mid 1) BSW 11

Sampling Date

Parameter	Unit	LOR	Mean	28/06/2012	18/07/2012	16/08/2012	13/09/2012	17/10/2012	21/11/2012	20/12/2012	19/02/2013	19/03/2013	15/04/2013	15/05/2013	4/02/2015	19/06/2013	21/08/2013	19/11/2013	20/02/2014	21/05/2014	19/08/2014	19/11/2014	28/04/2015	4/08/2015
pH Value	pH Unit	0.01	**7.4**	7.5	7.5	7.7	7.6	7.5	7.2	7.2	6.8	6.9	7	7.1	7.6	6.9	7.7	7.8	6.5	6.8	7.1	7.3	6.70	6.4
Electrical Conductivity @ 25°C	µS/cm	1	**670**	730	540	680	800	750	520	500	475	565	550	520	873	640	1290	1110	370	372	380	640	544.00	105
Suspended Solids (SS)	mg/L	1	**47**							57	5	3	3	5	544	5	12	0.07	271	7	13	266	139	18
Bicarbonate Alkalinity as CaCO3	mg/L	1	**122**								114	123	107	133	249	78	152	199	10	108	94	253	15	18
Carbonate Alkalinity as CaCO3	mg/L	1	**15**								<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1									<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**119**								114	123	107	133	249	78	152	32	10	108	94	253	15.00	18
Sulfate as SO4 - Turbidimetric	mg/L	1	**52**	61	49	48	57	40	44	45	42	61	44	46	22	74	140	76	75	24	32	18	171.00	12
Chloride	mg/L	1	**103**	117	81	115	145	132	52	45	50	68	68	56	117	92	237	195	53	33	30	58	38	8
Calcium	mg/L	1	**23**	19	16	18	22	24	27	26	20	26	26	26	19	16	32	29	15	17	14	38	30	5
Magnesium	mg/L	1	**20**	24	19	20	26	23	17	16	14	18	17	17	16	16	38	31	10	12	10	22	20	3
Potassium	mg/L	1	**7**	3	4	2	3	3	3	3	4	3	4	4	9	5	5	6	8	8	5	14	12.00	5
Sodium	mg/L	1	**79**	89	68	88	104	104	55	<0.001	54	69	65	58	49	79	175	147	47	45	42	68	46.00	9
Arsenic	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Cadmium	mg/L	0.0001	**0.0001**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00	<0.0001
Cobalt	mg/L	0.001	**0.002**								<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.003	<0.001	0.002
Copper	mg/L	0.001	**0.004**	<0.001	<0.001	<0.001	<0.001	0.008	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.019	0.002	<0.001	0.003	0.013	0.003	0.005	0.003	0.005	0.002
Iron	mg/L	0.05	**0.336**	0.15	0.33	0.21	0.14	0.3	<0.05	<0.05	0.2	0.07	0.08	0.13	0.37	0.42	<0.05	<0.05	0.12	1.15	0.2	<0.05	0.09	0.45
Lead	mg/L	0.001	**0.007**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.391**	0.06	0.073	0.097	0.233	0.258	0.348	0.244	0.241	0.105	0.126	0.231	0.419	0.093	0.179	0.005	0.629	0.354	0.216	2.91	0.69	0.257
Nickel	mg/L	0.001	**0.003**	<0.001	0.001	0.001	0.001	0.005	<0.001	<0.001	0.001	0.001	<0.001	<0.001	0.011	0.002	0.001	0.003	0.006	0.005	0.004	0.007	0.004	0.004
Zinc	mg/L	0.005	**0.025**	<0.005	<0.005	<0.005	<0.005	0.029	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.206	0.011	<0.005	<0.005	<0.005	0.025	0.032	0.008	0.03	0.007
Ammonia as N	mg/L	0.01	**0.19**								<0.01	0.02	<0.01	<0.01	0.52	0.03	<0.01	0.07	0.28	0.08	<0.01	1.23	0.29	0.1
Nitrite as N	mg/L	0.01	**0.04**								<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	0.06	0.06	<0.01
Nitrate as N	mg/L	0.01	**0.19**								0.07	0.02	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.93	0.08	0.08	0.02	2.26	0.02
Nitrite + Nitrate as N	mg/L	0.01	**0.20**								0.07	0.02	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.96	0.08	0.08	0.08	2.32	0.02
Total Kjeldahl Nitrogen as N	mg/L	0.1	**1.8**								0.3	0.3	<0.1	0.2	11.6	0.7	0.6	10.6	2.1	2	1.3	5.6	2	0.5
Total Nitrogen as N	mg/L	0.1	**1.7**								0.4	0.3	<0.1	0.2	11.6	0.7	0.6	2.2	3.1	2.1	1.4	5.7	4.3	0.5
Total Phosphorus as P	mg/L	0.01	**0.19**								0.03	<0.01	<0.01	<0.01	0.87	0.04	0.01	2.2	0.36	0.16	0.08	0.3	0.22	0.05
Ionic Balance	%	0.01	**2.97**								0.4	1.82	1.74	1.19	30.8	0.15	0.71	2.39	2.11	1.15	1.23	0.32	5.00	1.62
Total Anions	meq/L	0.01	**11.59**								4.56	5.65	5.43	5.19	8.73	5.69	12.6	199	3.66	4.09	3.39	7.07	4.93	2.36
Total Cations	meq/L	0.01	**6.78**								4.6	5.86	5.63	5.32	4.63	5.68	12.5	11.1	3.82	4	3.48	7.02	5.45	8.11

Table A2.2 (Cont'd)
Monitoring Results: Hawkins Creek (Mid 1) BSW 11

				Sampling Date																								
Parameter	**Unit**	**LOR**	**Mean**	**2/02/2016**	**11/05/2016**	**1/09/2016**	**26/09/2016**	**24/10/16**	**21/11/2016**	**12/12/2016**	**19/01/217**	**16/02/2017**	**14/03/2017**	**28/04/2017**	**17/05/2017**	**01/09/2016**	**14/06/2017**	**13/07/2017**	**22/08/2017**	**19/09/2017**	**17/10/2017**	**15/11/2017**	**15/11/2017**	**12/12/2017**	**16/01/2018**	**15/02/2018**	**15/03/2018**	**17/04/2018**
pH Value	pH Unit	0.01	**7.4**	7.1	7.1	7.5	7.4	7.5	7.6	7.2	7.4	7.2	7.6	7.2	7.1	7.5	7.2	7.2	7.6	7.9	8.7	8.2	8.2	7.5	8.3	8.4	7.5	7.6
Electrical Conductivity @ 25°C	µS/cm	1	**670**	265	267	810	273	381	570	556	565	535	530	576	569	810	587	704	980	991	1450	1560	1570	592	857	1260	332	289
Suspended Solids (SS)	mg/L	1	**47**	54	110	8	8	10	8	16	12	13	16	18	20	8	14	10	16	72	11	25	23	11	12	25	15	16
Bicarbonate Alkalinity as CaCO3	mg/L	1	**122**	55	85	107	50	78	116	120	135	120	118	116	117	107	120	125	122	146	188	222	217	75	159	242	73	94
Carbonate Alkalinity as CaCO3	mg/L	1	**15**	3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	27	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**119**	59	85	107	50	78	116	120	135	120	118	116	117	107	120	125	122	146	215	222	217	75	159	242	73	94
Sulfate as SO4 - Turbidimetric	mg/L	1	**52**	43	5	95	18	22	31	47	43	46	42	60	50	95	53	60	74	62	76	45	44	54	62	44	27	9
Chloride	mg/L	1	**103**	13	24	132	35	48	72	62	61	54	64	65	54	132	62	84	181	162	339	359	360	102	154	242	36	31
Calcium	mg/L	1	**23**	8	10	20	10	12	19	21	23	25	22	26	25	20	28	25	30	37	41	43	42	19	29	34	12	13
Magnesium	mg/L	1	**20**	6	8	30	8	13	18	19	19	15	15	17	17	30	18	18	26	30	40	41	41	17	25	35	9	10
Potassium	mg/L	1	**7**	8	20	8	3	3	2	3	3	3	3	4	3	8	4	5	6	4	15	15	14	10	15	28	9	12
Sodium	mg/L	1	**79**	12	16	102	31	45	68	59	60	57	56	59	59	102	61	87	110	116	184	204	201	70	101	166	32	26
Arsenic	mg/L	0.001	**0.002**	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.002	<0.001	<0.001	0.003	<0.001	0.001
Cadmium	mg/L	0.0001	**0.0001**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.002**	<0.001	0.003	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.003	0.002	0.004	<0.001	<0.001	0.001	<0.001	0.001
Copper	mg/L	0.001	**0.004**	0.001	0.002	0.005	0.002	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	0.001	0.002	0.001	0.002	0.001	<0.001	0.003	0.002	0.002	0.003	0.003
Iron	mg/L	0.05	**0.336**	0.07	0.44	0.52	0.62	0.82	0.55	0.06	0.22	0.08	0.06	0.07	<0.05	0.52	<0.05	0.08	0.23	<0.05	1.13	0.33	0.44	0.9	0.07	0.3	0.16	0.69
Lead	mg/L	0.001	**0.007**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.391**	0.119	1.1	0.089	0.076	0.19	0.223	0.221	0.171	0.122	0.118	0.203	0.165	0.089	0.18	0.216	0.312	0.366	1.76	1.54	1.53	0.431	0.088	0.658	0.016	0.237
Nickel	mg/L	0.001	**0.003**	0.001	0.007	0.004	0.003	0.003	0.004	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.004	0.001	0.002	0.002	0.002	0.004	0.005	0.004	0.005	0.003	0.004	0.003	0.004
Zinc	mg/L	0.005	**0.025**	0.012	0.006	0.009	<0.005	<0.005	0.006	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	<0.005	0.018	<0.005	<0.005	<0.005	<0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N	mg/L	0.01	**0.19**	0.03	1.87	0.06	0.05	0.05	<0.01	<0.01	<0.01	0.02	0.02	0.03	0.03	0.06	0.05	0.02	0.04	0.04	0.09	0.06	0.07	0.03	<0.01	0.09	<0.01	0.15
Nitrite as N	mg/L	0.01	**0.04**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
Nitrate as N	mg/L	0.01	**0.19**	0.05	0.02	0.01	<0.01	0.08	0.04	0.17	0.08	0.13	0.28	0.32	0.37	0.01	0.31	0.29	0.02	0.02	<0.01	0.03	<0.01	<0.01	0.02	0.04	0.01	0.03
Nitrite + Nitrate as N	mg/L	0.01	**0.20**	0.05	0.02	0.01	<0.01	0.08	0.04	0.17	0.08	0.13	0.28	0.32	0.37	0.01	0.31	0.29	0.02	0.02	<0.01	0.03	<0.01	<0.01	0.02	0.04	0.01	0.05
Total Kjeldahl Nitrogen as N	mg/L	0.1	**1.8**	0.8	4.6	0.2	1	0.9	0.9	0.3	0.5	0.3	0.4	0.5	0.4	0.2	0.3	0.5	1.1	1	1.8	2.2	2	1.7	1.2	3.6	1.6	2.1
Total Nitrogen as N	mg/L	0.1	**1.7**	0.8	4.6	0.2	1	1	0.9	0.5	0.6	0.4	0.7	0.8	0.8	0.2	0.6	0.8	1.1	1	1.8	2.2	2	1.7	1.2	3.6	1.6	2.2
Total Phosphorus as P	mg/L	0.01	**0.19**	0.09	0.53	0.01	0.05	0.04	<0.01	0.02	0.02	0.01	<0.01	0.03	0.02	0.01	0.02	0.06	0.1	0.07	0.07	0.13	0.11	0.11	0.04	0.21	0.11	0.13
Ionic Balance	%	0.01	**2.97**		1.67		4.7	4.26	1.25	0.79	1.61	1.95	0.33		3.8	1.67	3.53	4.11	2.88	3.76	5.88	2.38	2.79	1.32	3.1	0.25	1.24	
Total Anions	meq/L	0.01	**11.59**	2.48	7.84	2.36	3.37	4.99	5.12	5.31	4.88	5.04	5.4		4.9	7.84	5.25	6.12	9.08	8.78	15.4	15.5	15.4	5.5	8.81	12.6	3.04	2.94
Total Cations	meq/L	0.01	**6.78**	2.58	3.7	5.44	5.25	5.4	5.04	4.84	5.36				5.29	8.11	5.63	6.64	8.58	9.46	13.7	14.8	14.6	5.65	8.28	12.5	2.96	2.91

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Table A2.3
Monitoring Results: Hawkins Creek (Mid 2) BSW 07

Sampling Date

Parameter	Unit	LOR	Mean	28/06/2012	18/07/2012	15/08/2012	13/09/2012	17/10/2012	21/11/2012	20/12/2012	18/02/2013	19/03/2013	15/04/2013	15/05/2013	19/06/2013	21/08/2013	19/11/2013	17/02/2014	20/05/2014	19/08/2014	21/11/2014	5/02/2015	28/04/2015	4/08/2015	13/10/2015	2/02/2016	11/05/2016	30/08/2016
pH Value	pH Unit	0.01	**6.9**	7	6.8	7.3	7.6	6.9	6.9	6.8	6.7	6.7	6.6	6.8	6.8	6.9	7	6.6	6.4	6.7	6.70	6.5	6.6	6.60	8.10	6.50	6.60	7.1
Electrical Conductivity @ 25°C	µS/cm	1	**492**	740	525	635	645	575	500	460	430	460	435	450	535	600	460	456	446	452	478.00	507	495	526.00	525.00	523.00	618.00	925
Suspended Solids (SS)	mg/L	1	**13**							16	3	3	3	<2	<2	2	0.05	57	12	10	15.00	12	44	10.00	23.00	55.00	14.00	7
Bicarbonate Alkalinity as CaCO3	mg/L	1	**100**								100	97	97	100	79	95	98	95	84	79	109.00	96	80	68.00	111.00	98.00	113.00	114
Carbonate Alkalinity as CaCO3	mg/L	1	**9**								<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1									<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**98**								100	97	97	100	79	95	6	95	84	79	109.00	96	80	68.00	111.00	98.00	113.00	114
Sulfate as SO4 - Turbidimetric	mg/L	1	**43**	56	47	47	48	37	42	45	40	44	38	44	57	67	43	38	46	43	44.00	46	57	50.00	38.00	46.00	41.00	113
Chloride	mg/L	1	**59**	110	76	99	106	95	45	45	47	55	52	51	68	86	54	53	53	50	59.00	59	59	42.00	64.00	80.00	88.00	165
Calcium	mg/L	1	**26**	22	16	20	23	23	27	27	19	24	24	25	19	25	24	29	26	23	36.00	32	33	33.00	37.00	37.00	41.00	29
Magnesium	mg/L	1	**16**	25	18	20	21	17	15	15	13	15	13	14	14	18	14	15	15	13	16.00	17	18	17.00	20.00	20.00	20	33
Potassium	mg/L	1	**5**	3	4	3	3	4	4	5	6	5	5	5	4	4	5	7	5	4	5.00	5	6	4.00	5.00	8.00	6	6
Sodium	mg/L	1	**47**	92	62	77	75	70	44	<0.001	44	43	44	44	54	66	44	48	44	40	38.00	38	44	45.00	48.00	45.00	48.00	118
Arsenic	mg/L	0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	0.0001	**0.0002**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.002**								<0.001	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	**0.002**	0.004	<0.001	0.001	<0.001	0.005	<0.001	<0.001	0.001	0.005	<0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.001	<0.001	<0.001	0.00	<0.001	0.004
Iron	mg/L	0.05	**0.388**	0.2	0.31	0.23	0.14	0.28	0.19	0.17	0.16	2.93	0.32	0.17	0.5	0.25	0.06	0.22	0.15	0.56	0.14	0.92	0.2	0.47	0.21	0.12	0.27	0.44
Lead	mg/L	0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.309**	0.072	0.082	0.107	0.149	0.233	0.213	0.231	0.18	0.102	0.155	0.16	0.146	0.208	<0.001	0.87	0.201	0.24	1.08	0.457	0.081	0.23	0.33	0.24	0.17	0.143
Nickel	mg/L	0.001	**0.003**	0.001	0.001	0.001	0.002	0.011	<0.001	<0.001	0.001	0.014	<0.001	<0.001	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004
Zinc	mg/L	0.005	**0.022**	0.012	<0.005	<0.005	<0.005	0.103	0.009	<0.005	<0.005	0.021	<0.005	<0.005	0.008	<0.005	0.008	0.033	0.018	0.009	0.01	0.009	0.014	0.01	0.01	0.03	0.011	0.009
Ammonia as N	mg/L	0.01	**0.05**								<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.04	0.06	0.02	<0.01	0.08	<0.01	0.04	0.05	0.03	0.03	<0.01	0.04
Nitrite as N	mg/L	0.01	**0.02**								<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	**0.12**								0.1	0.06	0.02	0.02	0.03	0.04	0.04	0.01	0.01	0.01	0.03	0.02	0.13	0.19	0.05	0.20	<0.01	0.06
Nitrite + Nitrate as N	mg/L	0.01	**0.12**								0.1	0.06	0.02	0.02	0.03	0.04	0.04	0.01	0.01	0.01	0.03	0.02	0.13	0.19	0.05	0.20	<0.01	0.06
Total Kjeldahl Nitrogen as N	mg/L	0.1	**0.7**								0.3	0.3	<0.1	0.1	0.9	0.2	4.39	2	0.4	0.2	1.50	0.1	3.7	0.10	0.90	0.80	<0.1	1
Total Nitrogen as N	mg/L	0.1	**0.7**								0.4	0.4	<0.1	0.1	0.9	0.2	0.8	2	0.4	0.2	1.50	0.1	3.8	0.30	1.00	1.00	<0.1	1.1
Total Phosphorus as P	mg/L	0.01	**0.14**								0.02	<0.01	<0.01	<0.01	0.18	0.07	0.8	1.85	0.04	0.04	0.05	0.06	0.38	0.01	0.10	0.20	0.45	0.05
Ionic Balance	%	0.01	**2.01**								0.88	0.27	1.32	1	1.44	0.16	0.16	3.07	0.76	2.21	1.41	2.54	7.74			4.46	2.95	0.86
Total Anions	meq/L	0.01	**6.83**								4.16	4.41	4.2	4.35	4.68	5.72	98	4.65	4.5	3.88	4.76	4.54	4.45			5.17	5.59	9.28
Total Cations	meq/L	0.01	**4.46**								4.09	4.43	4.31	4.44	4.55	5.7	4.38	4.95	4.57	4.06	4.89	4.78	5.2			5.65	2.76	3.62

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Table A2.3 (Cont'd)
Monitoring Results: Hawkins Creek (Mid 2) BSW 07

Sampling Date

Parameter	Unit	LOR	Mean	27/09/2016	24/10/2016	21/11/2016	12/12/2016	19/01/2017	16/02/2017	14/03/2017	28/04/2017	17/05/2017	14/06/2017	14/07/2017	22/08/2017
pH Value	pH Unit	0.01	**6.9**	6.60	7.4	6.60	7.90	8.00	6.9	7	7	6.9	6.9	6.9	6.9
Electrical Conductivity @ 25°C	µS/cm	1	**492**	127.00	385	73.00	600.00	793.00	476	451	459	450	455	500	533
Suspended Solids (SS)	mg/L	1	**13**	4.00	8	18.00	21.00	12.00	8	6	14	6	8	9	10
Bicarbonate Alkalinity as CaCO3	mg/L	1	**100**	8.00	79	4.00	148.00	213.00	114	110	101	96	92	93	94
Carbonate Alkalinity as CaCO3	mg/L	1	**9**	<1	<1	<1	<1	9	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**98**	8.00	79	4.00	148.00	222.00	114	110	101	96	92	93	94
Sulfate as SO4 - Turbidimetric	mg/L	1	**43**	25.00	22	4.00	77.00	81.00	39	35	39	38	39	44	43
Chloride	mg/L	1	**59**	13.00	46	12.00	44.00	69.00	48	53	50	43	47	55	65
Calcium	mg/L	1	**26**	5.00	13	1.00	32.00	40.00	26	22	24	25	25	23	25
Magnesium	mg/L	1	**16**	4	13	1	24	36	14	14	13	14	14	14	15
Potassium	mg/L	1	**5**	4	3	6	3	4	4	4	4	4	5	4	4
Sodium	mg/L	1	**47**	10.00	42	5.00	46.00	70.00	45	44	42	40	42	56	52
Arsenic	mg/L	0.001	**0.001**	0.00	<0.001	<0.001	0.00	0.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	0.0001	**0.0002**	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.002**	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Copper	mg/L	0.001	**0.002**	0.00	0.002	<0.001	0.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	**0.388**	0.14	0.86	0.07	0.15	0.09	0.44	0.3	0.58	0.62	0.49	0.53	0.67
Lead	mg/L	0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.309**	0.05	0.188	0.02	0.06	0.12	0.412	0.209	0.329	0.279	0.342	0.316	0.523
Nickel	mg/L	0.001	**0.003**	0.002	0.002	<0.001	0.002	0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.005	**0.022**	0.13	0.009	0.01	0.023	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N	mg/L	0.01	**0.05**	<0.01	0.03	<0.01	<0.01	<0.01	0.04	0.04	0.04	0.08	0.09	0.05	0.11
Nitrite as N	mg/L	0.01	**0.02**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	**0.12**	<0.01	0.09	0.01	0.05	<0.01	0.06	0.08	0.14	0.25	0.2	0.29	0.25
Nitrite + Nitrate as N	mg/L	0.01	**0.12**	<0.01	0.09	0.01	0.05	<0.01	0.06	0.08	0.14	0.25	0.2	0.29	0.25
Total Kjeldahl Nitrogen as N	mg/L	0.1	**0.7**	0.6	0.7	0.5	0.8	0.7	0.4	0.3	0.5	0.3	1.2	0.4	0.3
Total Nitrogen as N	mg/L	0.1	**0.7**	0.6	0.8	0.5	0.8	0.7	0.5	0.4	0.6	0.6	1.4	0.7	0.6
Total Phosphorus as P	mg/L	0.01	**0.14**	0.02	0.04	0.03	0.01	0.05	0.04	<0.01	0.04	0.02	0.02	0.04	0.02
Ionic Balance	%	0.01	**2.01**		4.14	4.24	0.74	0.87	0.73	1.79	0.52	3.92	4.54	5.59	2.53
Total Anions	meq/L	0.01	**6.83**	2.46	3.33	4.84	4.71	4.62	4.44	4.42	4.24	3.92	3.98	4.32	4.61
Total Cations	meq/L	0.01	**4.46**	5.27	4.64	4.7	4.51	4.27	4.2		NG	4.24	4.35	4.84	4.85

Parameter	19/09/2017	17/10/2017	14/11/2017	12/12/2017	16/01/2018	15/02/2018	15/03/2018	17/04/2018	18/05/2018	18/06/2018	18/06/2018	18/07/2018	16/08/2018	20/09/2018	22/10/2018	22/10/2018	14/11/2018
pH Value	6.7	6.9	6.9	6.6	6.8	6.9	6.8	6.9	6.8	6.9	7	6.8	7.0	7.0	6.9	7.0	6.8
Electrical Conductivity @ 25°C	464	478	458	463	449	464	439	425	446	436	431	437	420	450	445	445	462
Suspended Solids (SS)	16	12	16	6	9	20	16	10	6	4	4	4	4	6	11	12	15
Bicarbonate Alkalinity as CaCO3	100	121	115	104	114	123	127	116	107	100	101	92	112	96	117	121	127
Carbonate Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	100	121	115	104	114	123	127	116	107	100	101	92	112	96	117	121	127
Sulfate as SO4 - Turbidimetric	36	36	33	44	28	29	26	27	33	34	34	36	35	31	27	26	32
Chloride	44	49	46	54	46	48	42	51	56	48	48	48	51	62	53	53	53
Calcium	24	27	26	27	28	29	27	27	29	26	26	25	27	26	26	26	28
Magnesium	12	18	14	17	14	15	12	12	14	12	12	12	13	12	13	13	14
Potassium	4	6	7	4	4	5	4	5	5	4	4	3	4	3	4	4	3
Sodium	40	42	38	40	40	38	38	38	40	36	37	36	38	37	37	36	38
Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	0.001	0.001	<0.001	<0.001	0.001	0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001
Copper	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	0.31	0.12	0.5	0.16	0.09	0.16	2.11	0.22	0.23	0.19	0.14	0.24	0.23	0.52	0.17	0.10	0.26
Lead	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	0.809	0.875	0.537	0.207	0.453	0.712	0.983	0.445	0.19	0.222	0.229	0.254	0.263	0.327	0.916	0.905	0.520
Nickel	0.002	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	<0.005	<0.005	<0.005	0.011	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N	0.06	0.03	0.12	<0.01	<0.01	0.03	<0.01	0.04	0.02	0.04	0.02	0.04	0.02	0.03	0.02	0.04	0.06
Nitrite as N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	0.3	0.18	0.17	0.74	0.04	0.29	0.05	0.04	0.08	0.12	0.11	0.19	0.09	0.03	0.08	0.09	0.02
Nitrite + Nitrate as N	0.3	0.18	0.17	0.74	0.04	0.29	0.05	0.04	0.09	0.12	0.12	0.19	0.09	0.03	0.08	0.09	0.02
Total Kjeldahl Nitrogen as N	0.4	0.4	0.8	0.2	0.2	0.6	0.1	0.3	<0.1	0.2	<0.1	0.3	0.1	0.2	0.4	0.2	0.4
Total Nitrogen as N	0.7	0.6	1	0.9	0.2	0.9	0.2	0.3	<0.1	0.3	0.1	0.5	0.2	0.2	0.5	0.3	0.4
Total Phosphorus as P	0.03	0.06	0.08	0.03	0.02	0.11	0.04	0.08	0.01	<0.01	0.02	<0.01	<0.01	0.02	0.05	0.03	0.05
Ionic Balance	0.48	2.78	<0.01	0.78	2.73	0.53	2.08	2.4	0.7	1.33	1.03	0.82	2.71	4.12	3.73	4.93	4.67
Total Anions	3.99	4.55	4.28	4.52	4.16	4.42	4.26	4.32	4.4	4.06	4.08	3.94	4.40	4.31	4.39	4.45	4.70
Total Cations	4.03	4.81	4.28	4.59	4.39	4.46	4.09	4.12	4.47	3.95	4	3.88	4.17	3.97	4.08	4.04	4.28

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Table A2.4
Monitoring Results: Hawkins Creek (Downstream 1) BSW 12

				Sampling Date																								
Parameter	**Unit**	**LOR**	**Mean**	**28/06/2012**	**18/07/2012**	**15/08/2012**	**13/09/2012**	**18/10/2012**	**21/11/2012**	**20/12/2012**	**19/02/2013**	**20/03/2013**	**15/04/2013**	**15/05/2013**	**20/06/2013**	**19/08/2013**	**19/11/2013**	**18/02/2014**	**21/05/2014**	**20/08/2014**	**19/11/2014**	**5/02/2015**	**29/04/2015**	**7/08/2015**	**14/10/2015**	**3/02/2016**	**11/05/2016**	**31/08/16**
pH Value	pH Unit	0.01	**7.4**	7.7	7.7	7.7	7.9	7.6	7.7	7.5	7	7	7.3	7.2	7.2	7.7	7.7	7.5	6.9	6.7	7.40	7.6	6.90	6.7	8	8.7	6.1	7.1
Electrical Conductivity @ 25°C	µS/cm	1	**492**	715	410	550	585	555	480	520	355	345	420	495	535	755	552	680	444	465	552.00	571	537.00	344	473	286	480	642
Suspended Solids (SS)	mg/L	1	**9**							14	<2	<2	<2	<2	4	2	<0.01	13	6	5	37.00	11	9.00	2	6	35	14	4
Bicarbonate Alkalinity as CaCO3	mg/L	1	**98**								79	68	91	100	76	101	125	199	73	72	144.00	127	82.00	53	74	60	30	84
Carbonate Alkalinity as CaCO3	mg/L	1	**12**								<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	11	12	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1									<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**97**								79	68	91	100	76	101	6	199	73	72	144.00	127	82.00	53	85	73	30	84
Sulfate as SO4 - Turbidimetric	mg/L	1	**47**	49	43	46	47	38	62	51	41	44	48	54	69	90	60	21	58	69	49.00	44	74.00	60	44	13	102	78
Chloride	mg/L	1	**57**	106	55	83	91	84	45	46	34	38	53	56	62	118	63	78	50	51	61.00	67	60.00	24	44	42	54	80
Calcium	mg/L	1	**22**	18	13	18	20	22	27	30	15	16	22	25	18	27	27	42	21	23	35.00	27	27.00	11	26	20	25	19
Magnesium	mg/L	1	**17**	20	14	17	19	18	17	19	11	12	14	16	14	23	20	29	16	17	21.00	20	21	8	19	14	15	19
Potassium	mg/L	1	**6**	3	5	3	4	4	4	5	7	5	6	10	5	6	4	14	6	8	6.00	5	9.00	4	8	5	9	8
Sodium	mg/L	1	**48**	72	48	64	64	67	46	<0.001	33	35	46	46	54	88	55	69	47	46	50.00	50	49.00	22	40	29	39	66
Arsenic	mg/L	0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.00	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	0.0001	**0.0002**	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.002**								<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Copper	mg/L	0.001	**0.003**	<0.001	<0.001	<0.001	<0.001	0.02	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.002	0.001	0.007	<0.001	<0.001	0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.001
Iron	mg/L	0.05	**0.209**	0.16	0.3	0.16	0.11	0.2	0.14	0.16	0.14	0.1	0.07	0.1	0.38	0.05	<0.05	0.12	0.1	0.07	<0.05	<0.05	0.07	0.06	0.24	0.31	0.08	0.16
Lead	mg/L	0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.203**	0.053	0.089	0.122	0.079	0.286	0.083	0.104	0.143	0.1	0.068	0.111	0.082	0.074	<0.001	0.134	0.078	0.094	0.01	0.008	0.11	0.022	0.217	0.181	0.361	0.058
Nickel	mg/L	0.001	**0.004**	<0.001	0.002	0.002	0.001	0.043	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.001	<0.001	<0.001	0.00	0.001	0.002	<0.001	0.001	0.001	0.004	0.002
Zinc	mg/L	0.005	**0.037**	<0.005	0.029	0.025	<0.005	0.478	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	0.018	0.006	0.006	0.012	0.01	0.018	0.01	<0.005	0.04	0.007	0.008	0.008	0.126	0.023
Ammonia as N	mg/L	0.01	**0.03**								0.02	<0.01	<0.01	<0.01	<0.01	0.02	0.04	0.03	0.04	0.01	0.05	0.02	0.02	0.02	<0.01	0.03	<0.01	0.03
Nitrite as N	mg/L	0.01									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	**0.04**								0.04	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.15	0.01	<0.01	<0.01	0.06	0.02	0.07	<0.01	0.02
Nitrite + Nitrate as N	mg/L	0.01	**0.04**								0.04	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.15	0.01	<0.01	<0.01	0.06	0.02	0.07	<0.01	0.02
Total Kjeldahl Nitrogen as N	mg/L	0.1	**0.6**								0.2	0.2	<0.1	0.2	0.4	0.5	5.49	0.7	0.5	0.3	1.40	0.8	0.40	<0.1	0.3	0.4	0.3	0.6
Total Nitrogen as N	mg/L	0.1	**0.5**								0.2	0.2	<0.1	0.2	0.4	0.5	0.7	0.7	0.5	0.4	1.40	0.8	0.40	<0.1	0.3	0.5	0.3	0.6
Total Phosphorus as P	mg/L	0.01	**0.06**								0.08	<0.01	0.08	<0.01	0.05	<0.01	0.7	0.09	0.02	0.02	0.04	0.07	0.02	<0.01	0.02	0.01	0.04	0.02
Ionic Balance	%	0.01	**2.48**								1.86	1.31	1.04	1.24	1.93	<0.01	0.34	6.16	2.37	2.26	1.62	0.46	5.48		3.54	1.88	0.24	
Total Anions	meq/L	0.01	**7.76**								3.39	3.35	4.31	4.7	4.7	7.22	125	6.93	4.35	4.54	5.62	5.34	4.87		4.41	4.25	5.56	2.2
Total Cations	meq/L	0.01	**4.73**								3.27	3.44	4.4	4.82	4.53	7.22	5.52	7.84	4.56	4.75	5.80	5.3	5.44		5.59	2.43	3.49	3.99

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Table A2.4 (Cont'd)
Monitoring Results: Hawkins Creek (Downstream 1) BSW 12

			Sampling Date																										
Parameter	**Unit**	**LOR**	**Mean**	**26/09/2016**	**24/10/2016**	**22/11/2016**	**12/12/2016**	**20/01/2017**	**16/02/2017**	**14/03/2017**	**28/04/2017**	**17/05/2017**	**14/06/2017**	**13/07/2017**	**22/08/2017**	**19/09/2017**	**17/10/2017**	**15/11/2017**	**12/12/2017**	**16/01/2018**	**15/02/2018**	**14/03/2018**	**17/04/2018**	**18/06/2018**	**18/07/2018**	**16/08/2018**	**20/09/2018**	**22/10/2018**	**14/11/2018**
pH Value	pH Unit	0.01	**7.4**	7.4	7.4	7.1	7.3	7.4	7.5	7.4	7.4	7.3	7.4	7.4	7.6	7.6	7.6	7.5	7.3	7.8	7.8	7	7.1	7.2	7.1	7.4	7.5	7.4	7.8
Electrical Conductivity @ 25°C	µS/cm	1	**492**	249	355	422	450	507	506	492	433	491	468	496	665	525	530	455	369	517	684	380	386	489	489	488	459	414	466
Suspended Solids (SS)	mg/L	1	**9**	6	5	3	3	3	3	2	4	3	2	1	4	3	8	56	6	9	12	8	9	2	2	2	9	38	11
Bicarbonate Alkalinity as CaCO3	mg/L	1	**98**	46	74	89	107	141	132	115	58	90	85	87	93	99	144	130	95	168	145	125	110	80	80	87	124	124	183
Carbonate Alkalinity as CaCO3	mg/L	1	**12**	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**97**	46	74	89	107	141	132	115	85	90	85	87	93	99	144	130	95	168	145	125	110	80	80	87	124	124	183
Sulfate as SO4 - Turbidimetric	mg/L	1	**47**	21	23	32	41	27	28	35	44	62	50	56	64	49	37	30	16	10	73	16	14	66	68	60	33	16	8
Chloride	mg/L	1	**57**	30	44	48	51	55	51	60	46	42	48	52	88	58	55	42	45	53	68	40	51	55	53	60	59	45	45
Calcium	mg/L	1	**22**	10	13	18	20	22	27	22	21	26	24	21	25	26	25	24	15	27	37	17	16	21	22	22	22	21	28
Magnesium	mg/L	1	**17**	8	13	15	18	20	17	17	14	17	16	15	19	19	19	16	11	19	24	12	13	16	16	17	14	14	19
Potassium	mg/L	1	**6**	4	3	3	3	2	3	5	5	4	5	5	5	5	8	7	6	6	6	6	6	7	6	7	5	6	7
Sodium	mg/L	1	**48**	27	39	41	44	48	46	44	38	42	42	52	69	47	45	40	31	50	65	36	34	42	42	43	37	35	41
Arsenic	mg/L	0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	0.0001	**0.0002**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	**0.003**	0.002	0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	**0.209**	0.56	0.75	0.4	0.19	0.25	0.15	0.15	0.11	0.08	0.14	0.11	0.21	0.2	0.26	0.13	0.84	0.06	<0.05	0.54	0.38	0.11	0.08	0.08	0.11	0.18	0.09
Lead	mg/L	0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.203**	0.05	0.081	0.563	0.295	0.3	0.255	0.227	0.283	0.249	0.211	0.216	0.268	0.256	0.554	0.418	0.641	0.029	0.021	0.669	0.751	0.164	0.15	0.095	0.168	0.387	0.231
Nickel	mg/L	0.001	**0.004**	0.003	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.002	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001
Zinc	mg/L	0.005	**0.037**	0.02	0.009	0.016	0.007	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N	mg/L	0.01	**0.03**	<0.01	0.04	<0.01	<0.01	<0.01	0.04	0.04	0.02	0.02	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.01
Nitrite as N	mg/L	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
Nitrate as N	mg/L	0.01	**0.04**	0.02	0.07	0.06	<0.01	0.04	<0.01	0.01	<0.01	0.03	<0.01	0.02	<0.01	<0.01	<0.01	0.05	<0.01	0.01	0.03	0.03	<0.01	<0.01	0.11	0.01	<0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	**0.04**	0.02	0.07	0.06	<0.01	0.04	<0.01	0.01	<0.01	0.03	<0.01	0.02	<0.01	<0.01	<0.01	0.05	<0.01	0.01	0.03	0.03	<0.01	<0.01	0.11	0.01	<0.01	<0.01	0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	**0.6**	0.8	0.8	0.5	0.2	0.3	0.4	0.2	0.2	<0.1	0.2	0.4	0.2	0.2	0.2	0.5	0.6	0.6	0.9	0.4	0.3	0.1	0.2	<0.1	0.2	<0.1	0.4
Total Nitrogen as N	mg/L	0.1	**0.5**	0.8	0.9	0.6	0.2	0.3	0.4	0.2	0.2	<0.1	0.2	0.4	0.2	0.2	0.2	0.6	0.6	0.6	0.9	0.4	0.3	0.1	0.3	<0.1	0.2	<0.1	0.4
Total Phosphorus as P	mg/L	0.01	**0.06**	0.03	0.03	<0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01	0.11	0.04	<0.01	0.06	0.02	0.02	<0.01	<0.01	<0.01	0.02	0.02	0.02
Ionic Balance	%	0.01	**2.48**	4.38	2.49	0.45	0.49	1.74	1.95	0.87		3.95	4.39	3.33	2.3	4.13	2.22	0.3	5.18	1.74	3.56	5.37	5.75	1.72	1.28	1.45	9.54	2.56	1.69
Total Anions	meq/L	0.01	**7.76**	3.2	3.8	4.43	4.93	4.66	4.72	3.91		4.27	4.09	4.37	5.67	4.63	5.2	4.41	3.5	5.06	6.34	3.96	3.93	4.52	4.51	4.68	4.83	4.08	5.09
Total Cations	meq/L	0.01	**4.73**	4.47	4.88	4.82	4.54	3.98				4.62	4.47	4.67	5.94	5.03	4.97	4.43	3.16	5.24	6.8	3.56	3.5	4.37	4.4	4.55	3.99	3.88	4.92

Table A2.5
Monitoring Results: Hawkins Creek (Downstream 2) BSW 19

Sampling Date

Parameter	Unit	LOR	Mean	19/07/2012	16/08/2012	14/09/2012	18/10/2012	21/11/2012	20/12/2012	19/02/2013	19/03/2013	16/04/2013	15/05/2013	25/06/2013	21/11/2013	20/08/2014	14/08/2015	31/08/2016	26/09/2016	26/10/2016	21/11/2016	12/12/2016	20/01/2017	16/02/2017	14/03/2017	22/08/2017	20/09/2017	17/10/2017	14/11/2017	13/12/2017	16/01/2018	14/03/2018	18/04/2018
pH Value	pH Unit	0.01	**7.1**	7.4	8	7.7	7.4	7.7	7.2	7.3	7	7.2	7.3	7.5	7.2	6.20	6.5	7.2	7.3	7.6	7.3	7	7.1	6.5	6.6	7.2	7.3	7	6.7	6.7	7.1	6.4	6.8
Electrical Conductivity @ 25°C	µS/cm	1	**506**	430	545	570	530	455	420	365	350	415	445	495	753	526.00	445	652	254	380	416	402	567	508	540	499	546	587	939	592	650	497	408
Suspended Solids (SS)	mg/L	1	**22**						11	3	3	6	2	46	0.07	26.00	8	43	6	5	5	4	74	12	47	9	26	28	68	14	21	52	30
Bicarbonate Alkalinity as CaCO3	mg/L	1	**87**							84	74	92	100	70	119	33.00	23	75	51	80	87	89	181	94	112	87	100	102	32	91	144	74	83
Carbonate Alkalinity as CaCO3	mg/L	1								<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1								<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**82**							84	74	92	100	70	13	33.00	23	75	51	80	87	89	181	94	112	87	100	102	32	91	144	74	83
Sulfate as SO4 - Turbidimetric	mg/L	1	**56**	45	46	46	35	42	35	32	40	39	45	57	71	114.00	118	87	21	29	31	34	8	43	32	42	44	45	261	63	39	89	48
Chloride	mg/L	1	**63**	58	77	87	85	47	43	38	36	52	49	60	123	59.00	30	102	30	46	48	50	64	58	80	60	62	79	110	80	78	49	46
Calcium	mg/L	1	**20**	14	17	20	20	22	18	14	15	18	21	17	31	14.00	21	21	10	16	16	13	20	20	20	19	23	25	52	23	23	19	15
Magnesium	mg/L	1	**17**	15	16	19	17	16	13	11	12	13	14	13	27	13.00	16	22	8	14	14	14	22	16	16	16	20	20	34	18	22	14	11
Potassium	mg/L	1	**6**	4	4	4	4	5	6	6	5	9	8	5	10	11	6	5	3	4	3	5	8	5	7	5	5	7	10	4	7	5	6
Sodium	mg/L	1	**51**	51	61	62	64	46	<0.001	36	35	44	47	48	73	60.00	42	73	26	44	40	40	58	52	53	47	51	59	63	51	71	52	42
Arsenic	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001
Cadmium	mg/L	0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.004**							<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.001	<0.001	<0.001	<0.001	0.003	0.005	0.002	<0.001	0.01	0.005
Copper	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.00	0.001	<0.001	0.002	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001
Iron	mg/L	0.05	**0.675**	0.32	0.21	0.28	0.34	0.16	0.2	0.23	0.3	0.13	0.11	0.51	0.16	0.20	0.09	0.32	0.64	0.84	0.64	0.39	0.79	1.1	4.89	0.5	0.53	0.5	0.21	1.06	0.44	3.33	0.84
Lead	mg/L	0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.442**	0.106	0.082	0.109	0.186	0.038	0.183	0.038	0.032	0.036	0.009	0.032	0.001	0.86	0.177	0.063	0.058	0.099	0.12	0.048	2.58	0.838	0.956	0.172	0.176	1.16	2.28	0.942	0.432	0.624	0.819
Nickel	mg/L	0.001	**0.002**	0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.00	0.004	0.003	0.003	0.003	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.002	0.004	0.001	0.001	0.005	0.002
Zinc	mg/L	0.005	**0.021**	0.025	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.008	0.014	0.041	0.061	0.014	0.019	0.006	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.026	0.006	<0.005	0.033	<0.005
Ammonia as N	mg/L	0.01	**0.05**							<0.01	<0.01	<0.01	<0.01	<0.01	0.07	0.03	0.02	<0.01	0.01	0.04	0.12	<0.01	0.02	<0.01	0.06	0.01	<0.01	<0.01	0.18	0.01	<0.01	<0.01	0.02
Nitrite as N	mg/L	0.01								<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	**0.04**							0.06	0.03	<0.01	<0.01	<0.01	0.02	0.13	0.03	0.02	0.02	0.03	0.04	<0.01	0.03	<0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.02	0.07	<0.01
Nitrite + Nitrate as N	mg/L	0.01	**0.04**							0.06	0.03	<0.01	<0.01	<0.01	0.02	0.13	0.03	0.02	0.02	0.03	0.04	<0.01	0.03	<0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.02	0.07	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	**1.1**							0.3	0.3	0.2	0.2	0.4	7.2	1.3	0.3	1.5	1	1.3	0.5	0.5	2.5	0.5	1	0.1	0.7	0.6	2.4	0.2	0.8	0.5	1
Total Nitrogen as N	mg/L	0.1	**0.8**							0.4	0.3	0.2	0.2	0.4	1.5	1.4	0.3	1.5	1	1.3	0.5	0.5	2.5	0.5	1	0.1	0.7	0.6	2.4	0.2	0.8	0.6	1
Total Phosphorus as P	mg/L	0.01	**0.16**							0.02	0.01	0.02	0.03	0.03	1.5	0.1	<0.01	0.1	0.16	0.06	<0.01	0.02	0.32	0.07	0.25	0.02	0.06	0.07	0.3	0.02	0.05	0.08	0.13
Ionic Balance	%	0.01	**2.39**							1.4	0.87	0.07	1.5	1.72	0.87	0.41		0.22		6.26	0.39	3.01	0.47	3.24	3.63	1.51	4.86	4.02	4.48	4.22	2.78	2.43	4.23
Total Anions	meq/L	0.01	**9.62**							3.42	3.33	4.12	4.32	4.28	119	4.70		6.19	2.3	3.5	3.74	3.9	5.59	4.41	5.16	4.3	4.66	5.2	9.18	5.39	5.89	4.71	3.96
Total Cations	meq/L	0.01	**4.75**							3.32	3.39	4.11	4.45	4.13	7.33	4.66		6.16	2.36	3.97	3.77	3.67	5.54	4.7	4.8	4.44	5.14	5.64	8.39	4.95	6.22	4.49	3.63

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Table A2.6
Monitoring Results: Lawsons Creek (Upstream 1) BSW 28

Sampling Date

Parameter	Unit	LOR	Mean	27/09/2016	26/10/2016	21/11/2016	12/12/2016	19/01/2017	16/02/2017	16/03/2017	28/04/2017	17/05/2017	15/06/2017	14/07/2017	23/08/2017	20/09/2017
pH Value	pH Unit	0.01	**7.9**	7.7	7.8	7.9	8	8	8.1	8.1	7.8	7.9	8	8	8.1	8.1
Electrical Conductivity @ 25°C	µS/cm	1	**980**	379	522	600	791	1020	1160	1210	840	907	945	978	1030	1090
Suspended Solids (SS)	mg/L	1	**16**	7	8	21	10	14	11	17	8	8	7	9	8	18
Bicarbonate Alkalinity as CaCO3	mg/L	1	**254**	80	128	148	220	309	330	306	210	239	252	264	275	275
Carbonate Alkalinity as CaCO3	mg/L	1	**12**	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**256**	80	128	148	220	309	331	306	210	239	252	264	275	275
Sulfate as SO4 - Turbidimetric	mg/L	1	**114**	41	41	77	79	80	104	130	102	88	100	104	115	111
Chloride	mg/L	1	**94**	32	50	44	70	84	105	119	68	68	73	77	85	81
Calcium	mg/L	1	**54**	20	26	32	39	60	63	52	50	53	58	53	59	62
Magnesium	mg/L	1	**40**	14	22	24	37	43	51	53	34	37	40	35	42	46
Potassium	mg/L	1	**5**	3	3	3	4	6	8	9	4	3	4	4	4	3
Sodium	mg/L	1	**90**	33	49	46	71	84	103	120	70	80	84	103	93	97
Arsenic	mg/L	0.001	**0.002**	<0.001	0.001	0.001	0.002	0.003	0.003	0.003	<0.001	0.001	<0.001	0.001	<0.001	<0.001
Cadmium	mg/L	0.0001	**0.0001**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	**0.002**	0.002	0.002	0.002	0.002	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.001	<0.001	<0.001
Iron	mg/L	0.05	**0.161**	0.48	0.49	0.15	0.1	<0.05	0.06	0.08	0.08	0.05	<0.05	<0.05	0.06	0.07
Lead	mg/L	0.001	**0.002**	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.139**	0.056	0.088	0.06	0.118	0.177	0.118	0.123	0.059	0.058	0.055	0.043	0.027	0.053
Nickel	mg/L	0.001	**0.002**	0.003	0.004	0.002	0.001	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.002
Zinc	mg/L	0.005	**0.011**	0.007	<0.005	0.023	<0.005	0.006	0.012	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005
Ammonia as N	mg/L	0.01	**0.03**	0.03	0.05	<0.01	<0.01	<0.01	0.04	0.02	0.02	0.02	0.06	<0.01	<0.01	<0.01
Nitrite as N	mg/L	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	**0.03**	0.05	0.04	0.05	<0.01	0.04	<0.01	0.01	0.06	0.02	<0.01	<0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	**0.03**	0.05	0.04	0.05	<0.01	0.04	<0.01	0.01	0.06	0.02	<0.01	<0.01	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	**0.7**	1	0.7	0.8	0.6	1	1	1.1	0.4	0.3	0.3	0.3	0.2	0.4
Total Nitrogen as N	mg/L	0.1	**0.7**	1	0.7	0.8	0.6	1	1	1.1	0.5	0.3	0.3	0.3	0.2	0.4
Total Phosphorus as P	mg/L	0.01	**0.06**	0.03	0.04	0.01	0.06	0.06	0.37	0.05	0.02	0.01	0.02	0.01	<0.01	0.02
Ionic Balance	%	0.01	**3.06**	4.37	4.88	1.32	1.03	0.64	1.2	0.93	1.22	4.06	4.01	2.51	1.26	5.1
Total Anions	meq/L	0.01	**10.15**	3.35	4.82	5.8	8.02	10.2	11.7	12.2	8.24	8.52	9.18	9.61	10.3	10.1
Total Cations	meq/L	0.01	**10.01**	3.66	5.32	5.65	8.18	10.3	12	12.4	8.44	9.25	9.94	10.1	10.5	11.2

Parameter	Unit	LOR	Mean	18/10/2017	15/11/2017	12/12/2017	17/01/2018	15/02/2018	14/03/2018	18/04/2018	18/05/2018	18/06/2018	18/07/2018	16/08/2018	16/08/2018	20/09/2018	22/10/2018	14/11/2018	14/11/2018
pH Value	pH Unit	0.01	**7.9**	8	8	7.7	8	8.4	7.3	7.7	7.9	8	8	8.0	8.0	8.0	8.0	8.0	7.9
Electrical Conductivity @ 25°C	µS/cm	1	**980**	1200	1280	761	1040	1260	940	1000	1150	1180	1260	1340	1340	1200	1180	1270	1270
Suspended Solids (SS)	mg/L	1	**16**	16	16	34	32	39	10	16	30	13	12	19	20	18	38	46	46
Bicarbonate Alkalinity as CaCO3	mg/L	1	**254**	345	342	192	310	375	229	253	266	266	231	261	262	256	259	342	341
Carbonate Alkalinity as CaCO3	mg/L	1	**12**	8	5	<1	<1	24	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**256**	353	347	192	310	399	229	253	266	266	231	261	262	256	259	342	341
Sulfate as SO4 - Turbidimetric	mg/L	1	**114**	145	192	67	95	76	117	121	174	209	257	299	288	182	188	122	110
Chloride	mg/L	1	**94**	123	129	74	111	140	122	112	128	139	139	153	186	126	128	146	146
Calcium	mg/L	1	**54**	61	70	43	58	65	53	56	59	68	71	76	77	65	64	71	78
Magnesium	mg/L	1	**40**	47	54	29	42	50	38	42	43	51	54	56	57	48	47	55	59
Potassium	mg/L	1	**5**	5	5	5	6	9	7	6	5	6	5	6	6	4	5	5	6
Sodium	mg/L	1	**90**	103	124	72	100	138	88	95	94	107	110	116	117	106	103	121	132
Arsenic	mg/L	0.001	**0.002**	0.002	<0.001	0.002	0.002	0.004	0.004	0.002	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.002
Cadmium	mg/L	0.0001	**0.0001**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	**0.161**	0.06	<0.05	0.06	<0.05	0.07	0.53	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.139**	0.093	0.051	0.245	0.06	0.145	1.06	0.232	0.105	0.107	0.055	0.113	0.118	0.067	0.262	0.242	0.263
Nickel	mg/L	0.001	**0.002**	0.002	0.001	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.003	0.002	0.002	0.001	0.003	0.002	0.002
Zinc	mg/L	0.005	**0.011**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N	mg/L	0.01	**0.03**	<0.01	0.01	<0.01	<0.01	0.03	0.04	0.04	<0.01	0.02	0.01	<0.01	0.02	<0.01	0.05	<0.01	0.01
Nitrite as N	mg/L	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	**0.03**	<0.01	<0.01	<0.01	0.01	0.03	0.02	<0.01	0.03	0.01	0.05	<0.01	<0.01	<0.01	0.09	0.07	0.06
Nitrite + Nitrate as N	mg/L	0.01	**0.03**	<0.01	<0.01	<0.01	0.01	0.03	0.02	<0.01	0.03	0.01	0.05	<0.01	<0.01	<0.01	0.09	0.07	0.06
Total Kjeldahl Nitrogen as N	mg/L	0.1	**0.7**	0.4	0.6	0.8	0.9	1.5	0.6	0.6	0.9	0.4	0.5	0.3	0.3	0.4	0.3	0.7	0.7
Total Nitrogen as N	mg/L	0.1	**0.7**	0.4	0.6	0.8	0.9	1.5	0.6	0.6	0.9	0.4	0.6	0.3	0.3	0.4	0.4	0.8	0.8
Total Phosphorus as P	mg/L	0.01	**0.06**	0.02	0.05	0.07	0.06	0.15	0.06	0.05	0.07	0.08	0.02	0.01	0.02	0.03	0.02	0.05	0.05
Ionic Balance	%	0.01	**3.06**	8.06	3.96	3.13	2.02	0.32	3.33	0.92	7.95	4.57	3.68	7.34	8.93	2.26	4.22	0.12	5.10
Total Anions	meq/L	0.01	**10.15**	13.5	14.6	7.32	11.3	13.5	10.4	10.7	12.5	13.6	13.9	15.8	16.5	12.4	12.7	13.5	13.2
Total Cations	meq/L	0.01	**10.01**	11.5	13.4	7.79	10.8	13.6	9.78	10.5	10.7	12.4	12.9	13.6	13.8	11.9	11.7	13.5	14.6

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Table A2.7
Monitoring Results: Lawsons Creek (Upstream 2) BSW 22

Sampling Date

Parameter	Unit	LOR	Mean	29/06/2012	18/07/2012	15/08/2012	14/09/2012	18/10/2012	21/11/2012	20/12/2012	19/02/2013	19/03/2013	15/04/2013	14/05/2013	20/06/2013	21/08/2013	19/11/2013
pH Value	pH Unit	0.01	**7.8**	7.9	7.8	8.1	8	7.8	7.8	8	7.9	7.6	7.8	7.7	7.6	7.9	8
Electrical Conductivity @ 25°C	µS/cm	1	**905**	980	515	750	880	965	1040	1050	805	820	880	940	995	1040	1160
Suspended Solids (SS)	mg/L	1	**14**							73	13	3	6	6	<2	8	0.03
Bicarbonate Alkalinity as CaCO3	mg/L	1	**213**								193	180	203	252	175	200	302
Carbonate Alkalinity as CaCO3	mg/L	1	**18**								<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1									<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**211**								193	180	203	252	175	200	<5
Sulfate as SO4 - Turbidimetric	mg/L	1	**106**	173	73	122	110	111	124	74	108	121	104	90	137	138	134
Chloride	mg/L	1	**99**	117	51	86	113	139	122	113	79	80	93	94	116	128	128
Calcium	mg/L	1	**50**	40	23	36	42	51	59	54	41	43	55	62	46	54	64
Magnesium	mg/L	1	**38**	45	24	36	39	42	45	46	33	36	37	39	40	42	48
Potassium	mg/L	1	**4**	4	4	3	4	4	4	4	5	4	4	5	5	4	5
Sodium	mg/L	1	**86**	84	44	71	80	103	102	<0.001	72	80	92	86	89	98	107
Arsenic	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.001	0.001	0.001	0.001	<0.001	<0.001
Cadmium	mg/L	0.0001	**0.0001**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.001**								<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	**0.002**	<0.001	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.002
Iron	mg/L	0.05	**0.169**	0.09	0.32	0.22	0.08	0.08	<0.05	<0.05	0.09	0.09	0.07	0.08	0.06	<0.05	<0.05
Lead	mg/L	0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.145**	0.042	0.071	0.083	0.157	0.212	0.123	0.062	0.127	0.073	0.122	0.22	0.053	0.108	<0.001
Nickel	mg/L	0.001	**0.002**	<0.001	0.001	0.001	0.001	<0.001	<0.001	<0.001	0.001	0.002	0.001	<0.001	<0.001	<0.001	0.001
Zinc	mg/L	0.005	**0.007**	<0.005	<0.005	<0.005	<0.005	0.008	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	0.005	<0.005
Ammonia as N	mg/L	0.01	**0.02**								<0.01	<0.01	<0.01	<0.01	0.01	0.02	0.03
Nitrite as N	mg/L	0.01	**0.03**								<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	**0.07**								0.06	0.02	<0.01	0.01	<0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	**0.07**								0.06	0.02	<0.01	0.01	<0.01	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	**1.0**								0.5	0.9	0.2	0.2	0.5	0.6	11.9
Total Nitrogen as N	mg/L	0.1	**0.6**								0.6	0.9	0.2	0.2	0.5	0.6	0.4
Total Phosphorus as P	mg/L	0.01	**0.07**								0.04	0.3	0.02	<0.01	0.02	0.03	0.4
Ionic Balance	%	0.01	**2.03**								1.92	1.85	1.89	3.09	0.19	0.16	2.1
Total Anions	meq/L	0.01	**22.96**								8.33	8.37	9.52	9.56	9.62	10.5	302
Total Cations	meq/L	0.01	**9.80**								8.02	8.69	9.89	10.2	9.59	10.5	12.4

Parameter	Unit	LOR	Mean	18/02/2014	22/05/2014	20/08/2014	20/11/2014	8/02/2015	1/05/2015	7/08/2015	14/10/2015	3/02/2016	12/05/2016	08/09/2016	27/09/2016	27/10/2016	21/11/2016	12/12/2016	19/01/2017
pH Value	pH Unit	0.01	**7.8**	7.9	7.4	7.5	7.40	7.7	7.7	7.30	7.70	8.50	7.8	7.5	7.4	7.6	7.4	7.6	8.4
Electrical Conductivity @ 25°C	µS/cm	1	**905**	961	1040	1140	1200.00	945	1010	991.00	1060.00	648.00	992	389	300	549	565	990	1800
Suspended Solids (SS)	mg/L	1	**14**	5	21	2	6.00	6	10	4.00	44.00	94.00	3	8	12	5	6	5	14
Bicarbonate Alkalinity as CaCO3	mg/L	1	**213**	290	200	171	298.00	252	264	98.00	241.00	205.00	274	75	59	136	142	308	67
Carbonate Alkalinity as CaCO3	mg/L	1	**18**	<1	<1	<1	<1	18	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**211**	290	200	171	298.00	270	264	98.00	241.00	205.00	274	75	59	136	142	308	67
Sulfate as SO4 - Turbidimetric	mg/L	1	**106**	51	171	195	180.00	72	99	180.00	166.00	24.00	72	49	34	45	45	73	359
Chloride	mg/L	1	**99**	106	107	148	155.00	96	127	56.00	112.00	56.00	119	35	28	52	51	90	315
Calcium	mg/L	1	**50**	54	62	63	87.00	58	65	59.00	70.00	36.00	55	20	13	27	27	48	63
Magnesium	mg/L	1	**38**	46	44	48	52.00	40	46	44.00	48.00	26.00	42	15	12	24	23	40	65
Potassium	mg/L	1	**4**	6	4	5	4.00	4	4	5.00	4.00	3.00	6	3	3	3	3	3	4
Sodium	mg/L	1	**86**	105	95	114	116.00	83	101	98.00	97.00	52.00	99	36	28	51	53	106	217
Arsenic	mg/L	0.001	**0.002**	0.004	<0.001	<0.001	<0.001	0.002	0.001	<0.001	0.00	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.002	0.001
Cadmium	mg/L	0.0001	**0.0001**	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Copper	mg/L	0.001	**0.002**	0.002	<0.001	<0.001	<0.001	0.004	<0.001	0.00	<0.001	<0.001	<0.001	0.002	0.002	0.001	<0.001	0.001	0.001
Iron	mg/L	0.05	**0.169**	<0.05	0.05	0.08	<0.05	<0.05	<0.05	0.11	0.06	0.07	0.07	0.51	0.55	0.46	0.55	0.1	<0.05
Lead	mg/L	0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.145**	0.068	0.103	0.093	0.08	0.041	0.047	0.08	0.42	0.18	0.066	0.037	0.088	0.127	0.63	0.711	0.393
Nickel	mg/L	0.001	**0.002**	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.006	0.002	0.003	0.001	0.005
Zinc	mg/L	0.005	**0.007**	0.009	0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	0.01	0.007	<0.005	<0.005	<0.005	0.007	0.005	<0.005
Ammonia as N	mg/L	0.01	**0.02**	0.03	0.04	0.01	0.02	0.02	0.02	0.01	0.04	0.01	<0.01	<0.01	0.01	0.04	0.01	0.01	0.01
Nitrite as N	mg/L	0.01	**0.03**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	**0.07**	<0.01	0.06	0.03	<0.01	0.03	<0.01	<0.01	0.03	0.45	<0.01	0.09	0.03	0.01	0.04	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	**0.07**	<0.01	0.06	0.03	<0.01	0.03	<0.01	<0.01	0.03	0.45	<0.01	0.09	0.03	0.01	0.04	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	**1.0**	0.7	0.4	0.4	0.60	0.5	0.4	0.20	0.30	0.40	0.2	0.7	1.2	2.1	0.7	0.5	1.2
Total Nitrogen as N	mg/L	0.1	**0.6**	0.7	0.5	0.4	0.60	0.5	0.4	0.20	0.30	0.80	0.2	0.8	1.2	2.1	0.7	0.5	1.2
Total Phosphorus as P	mg/L	0.01	**0.07**	0.12	0.04	0.03	0.02	0.03	0.02	<0.01	0.03	0.04	0.01	0.03	0.11	0.04	0.02	0.05	0.06
Ionic Balance	%	0.01	**2.03**	5.63	1.73	2.21	1.10	1.51	2.69			0.79	1.56	3.7		0.31			
Total Anions	meq/L	0.01	**22.96**	10	10.6	11.6	14.10	9.6	10.9			6.18	10.3	3.35		3.29			
Total Cations	meq/L	0.01	**9.80**	11.2	11	12.2	13.80	9.9	11.5			6.27	10.7	3.31		8.51			

Parameter	Unit	LOR	Mean	16/02/2017	14/03/2017	28/04/2017	18/05/2017	15/06/2017	14/07/2017	23/08/2017	20/09/2017	18/10/2017	15/11/2017	17/01/2018	16/02/2018	16/02/2018	14/03/2018	18/04/2018
pH Value	pH Unit	0.01	**7.8**	7.9	8.1	7.6	7.7	7.8	7.8	7.8	7.9	7.9	7.90	7.9	8.2	8.1	7.5	7.6
Electrical Conductivity @ 25°C	µS/cm	1	**905**	843	828	823	874	918	948	942	975	1000	963	898	962	964	906	911
Suspended Solids (SS)	mg/L	1	**14**	14	4	4	3	3	5	4	3	5	7	4	10	11	11	10
Bicarbonate Alkalinity as CaCO3	mg/L	1	**213**	337	339	224	238	248	257	260	277	342	347	339	352	336	248	319
Carbonate Alkalinity as CaCO3	mg/L	1	**18**	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	16	15	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**211**	337	339	224	238	248	257	260	277	342	347	339	368	351	248	319
Sulfate as SO4 - Turbidimetric	mg/L	1	**106**	20	15	88	80	86	88	83	77	75	67	20	16	18	115	71
Chloride	mg/L	1	**99**	59	68	69	72	70	77	79	76	104	68	72	108	113	111	101
Calcium	mg/L	1	**50**	51	51	51	55	56	51	56	63	59	60	55	45	45	52	53
Magnesium	mg/L	1	**38**	35	34	32	38	36	35	37	43	38	39	36	40	41	36	36
Potassium	mg/L	1	**4**	4	3	4	3	3	3	4	3	4	3	4	4	4	5	5
Sodium	mg/L	1	**86**	74	72	68	77	78	95	84	88	90	85	84	103	105	82	82
Arsenic	mg/L	0.001	**0.002**	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.002	0.002	0.003	0.002	0.001
Cadmium	mg/L	0.0001	**0.0001**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	**0.002**	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Iron	mg/L	0.05	**0.169**	<0.05	<0.05	0.12	0.08	0.07	0.05	0.10	0.10	0.08	0.08	<0.05	0.09	0.09	0.18	0.08
Lead	mg/L	0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.145**	0.033	0.037	0.086	0.063	0.095	0.063	0.086	0.097	0.324	0.021	0.051	0.116	0.111	0.308	0.151
Nickel	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.001	0.002	<0.001
Zinc	mg/L	0.005	**0.007**	0.017	<0.005	0.009	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N	mg/L	0.01	**0.02**	0.06	0.01	0.04	0.03	0.03	0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.02	0.02	<0.01	<0.01
Nitrite as N	mg/L	0.01	**0.03**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	**0.07**	<0.01	0.02	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.02	0.02	0.03	0.02	<0.01
Nitrite + Nitrate as N	mg/L	0.01	**0.07**	<0.01	0.02	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.02	0.02	0.03	0.02	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	**1.0**	1.5	0.4	0.4	0.7	0.3	0.3	0.2	0.3	0.4	0.5	0.4	0.8	0.8	0.7	0.5
Total Nitrogen as N	mg/L	0.1	**0.6**	1.5	0.4	0.4	0.7	0.3	0.3	0.2	0.3	0.4	0.5	0.4	0.8	0.8	0.7	0.5
Total Phosphorus as P	mg/L	0.01	**0.07**	0.07	<0.01	0.02	0.02	0.08	0.02	0.01	0.02	0.01	0.08	0.01	0.06	0.06	0.05	0.03
Ionic Balance	%	0.01	**2.03**	2.57	0.09		4.77	2.82	2.64	2.37	6.57	5.79	1.33	1.30	2.94	1.37	6.22	6.99
Total Anions	meq/L	0.01	**22.96**	9	8.25		8.45	8.72	9.14	9.15	9.28	11.3	10.2	9.22	10.7	10.6	10.5	10.7
Total Cations	meq/L	0.01	**9.80**				9.3	9.23	9.63	9.60	10.6	10.1	9.98	9.46	10.1	10.3	9.25	9.30

Table A2.8
Monitoring Results: Lawsons Creek (Updstream 3) BSW 21

Parameter	Unit	LOR	Mean	29/06/2012	18/07/2012	15/08/2012	14/09/2012	18/10/2012	21/11/2012	20/12/2012	19/02/2013	19/03/2013	15/04/2013	14/05/2013	20/06/2013	21/08/2013	19/11/2013	18/02/2014	22/05/2014	20/08/2014	20/11/2014	8/02/2015	1/05/2015	4/08/2015	14/10/2015	03/02/2016	12/05/2016	05/09/2016	28/09/2016
			Sampling Date																										
pH Value	pH Unit	0.01	**7.6**	7.3	7.6	8	7.9	7.7	7.7	8	7.6	7.4	7.7	7.7	7.3	7.7	8	7.8	7.3	7.2	7.40	7.5	7.50	7.10	7.6	7.4	7.7	7.2	7.5
Electrical Conductivity @ 25°C	µS/cm	1	**1146**	920	510	750	885	1030	1110	1380	800	805	945	1080	1280	1070	1440	1710	1260	1200	1560.00	1890	1420.00	1020.00	1380	1544	1410	272	376
Suspended Solids (SS)	mg/L	1	**24**							13	11	10	5	3	5	12	0.11	15	48	14	14.00	190	10.00	3.00	8	88	6	18	7
Bicarbonate Alkalinity as CaCO3	mg/L	1	**257**								168	155	213	316	161	195	503	390	192	133	446.00	361	289.00	72.00	149	373	281	46	72
Carbonate Alkalinity as CaCO3	mg/L	1									<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	5	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1									<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**222**								168	155	213	316	161	195	16	390	192	133	446.00	361	289.00	72.00	154	373	281	46	72
Sulfate as SO4 - Turbidimetric	mg/L	1	**157**	156	75	120	112	143	133	77	118	126	101	93	248	139	114	229	236	202	201.00	314	248.00	114.00	232	214	225	38	41
Chloride	mg/L	1	**132**	120	57	92	124	157	132	115	87	88	97	104	159	139	129	192	152	184	195.00	236	173.00	38.00	152	159	170	30	35
Calcium	mg/L	1	**58**	31	20	30	37	48	59	75	36	37	52	64	50	50	74	93	70	51	95.00	104	97.00	37.00	85	101	98	11	17
Magnesium	mg/L	1	**46**	42	23	35	40	46	48	49	34	36	38	40	58	42	48	62	55	50	58.00	70	54	33	62	64	51	10	14
Potassium	mg/L	1	**5**	4	5	3	4	5	4	3	6	5	5	6	6	5	6	3	7	5	4.00	3	2.00	4.00	6	4	3	4	3
Sodium	mg/L	1	**123**	83	48	70	84	114	126	<0.001	79	82	107	113	123	109	177	228	128	129	192.00	225	167.00	74.00	154	190	159	26	36
Arsenic	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.003	<0.001	<0.001	0.00	0.002	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	0.0001	**0.0010**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.001**								<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.002	<0.001	0.001	<0.001	0.001	0.00	0.00	<0.001	<0.001	<0.001	0.002	0.003
Iron	mg/L	0.05	**0.120**	0.17	0.36	0.2	0.08	0.07	<0.05	<0.05	0.13	0.09	0.07	0.06	0.09	<0.05	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	0.06	0.10	<0.05	<0.05	0.61	0.55
Lead	mg/L	0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.285**	0.125	0.129	0.146	0.419	0.575	0.61	0.117	0.452	0.29	0.317	0.31	0.458	0.245	<0.001	0.653	0.203	0.098	0.15	0.279	0.05	0.06	1.38	0.020	0.249	0.075	0.122
Nickel	mg/L	0.001	**0.002**	<0.001	0.002	0.001	0.002	0.001	0.001	<0.001	0.002	0.004	<0.001	<0.001	0.002	<0.001	0.001	0.001	0.001	0.001	0.00	<0.001	<0.001	0.002	0.002	<0.001	<0.001	0.003	0.004
Zinc	mg/L	0.005	**0.050**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	0.304	<0.005	0.005	0.006	0.01	0.013	<0.005	<0.005	0.01	<0.005	0.006	0.008	<0.005	0.014	0.013
Ammonia as N	mg/L	0.01	**0.03**								<0.01	0.03	<0.01	<0.01	<0.01	0.02	0.06	0.01	0.04	0.03	0.04	0.02	0.02	<0.01	0.02	0.01	<0.01	0.12	0.04
Nitrite as N	mg/L	0.01									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	**0.07**								0.05	0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.15	0.14	0.05	<0.01	<0.01	0.08	0.04	1.24	<0.01	0.09	<0.01
Nitrite + Nitrate as N	mg/L	0.01	**0.07**								0.05	0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.15	0.14	0.05	<0.01	<0.01	0.08	0.04	1.24	<0.01	0.09	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	**1.7**								0.8	1.2	0.3	0.1	0.5	0.5	15.5	0.6	0.7	0.8	1.00	0.5	0.40	0.60	0.4	0.3	0.1	1.0	1.0
Total Nitrogen as N	mg/L	0.1	**0.7**								0.8	1.2	0.3	0.1	0.5	0.5	1.4	0.6	0.8	0.9	1.00	0.5	0.40	0.70	0.4	1.5	0.1	1.1	1.0
Total Phosphorus as P	mg/L	0.01	**0.20**								0.07	0.32	<0.01	<0.01	0.02	0.03	1.4	0.08	0.04	0.04	0.04	0.1	0.02	<0.01	0.03	0.02	0.01	0.07	0.04
Ionic Balance	%	0.01	**1.84**								0.52	1.79	3.38	1.62	0.38	0.5	1.82	4.65	2.71	1.4	1.73	0.97	2.40		18.7	3.16		5.24	4.46
Total Anions	meq/L	0.01	**50.91**								8.27	8.2	9.81	11.2	12.9	10.7	503	18	13	12	18.60	20.4	15.80		16.1	15.1	2.56	3.28	4.03
Total Cations	meq/L	0.01	**13.83**								8.18	8.5	10.5	11.6	12.8	10.8	16.1	19.7	13.8	12.4	18.00	20.8	16.6		2.60	3.64	4.41	5.62	10.4

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Table A2.8 (Cont'd)
Monitoring Results: Lawsons Creek (Upstream 3) BSW 21

Sampling Date

Parameter	Unit	LOR	Mean	24/10/2016	21/11/2016	12/12/2016	20/01/2017	14/03/2017	28/04/2017	17/05/2017	14/06/2017	14/07/2017	22/08/2017	20/09/2017
pH Value	pH Unit	0.01	**7.6**	7.6	7.4	7.6	8.0	8.0	7.4	7.5	7.4	7.7	7.4	7.7
Electrical Conductivity @ 25°C	µS/cm	1	**1146**	450	565	990	1360	1390	1020	916	1140	920	1410	1160
Suspended Solids (SS)	mg/L	1	**24**	12	6	5	8	13	6	3	3	6	7	4
Bicarbonate Alkalinity as CaCO3	mg/L	1	**257**	93	142	308	475	518	257	250	288	247	353	336
Carbonate Alkalinity as CaCO3	mg/L	1		<1	<1	<1	18	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**222**	93	142	308	493	518	257	250	288	247	353	336
Sulfate as SO4 - Turbidimetric	mg/L	1	**157**	34	45	73	75	75	110	69	121	73	170	96
Chloride	mg/L	1	**132**	52	51	90	122	117	106	73	110	81	144	108
Calcium	mg/L	1	**58**	18	27	48	66	67	57	46	70	44	82	64
Magnesium	mg/L	1	**46**	19	23	40	46	44	36	32	40	33	42	44
Potassium	mg/L	1	**5**	3	3	3	2	2	4	1	4	4	3	4
Sodium	mg/L	1	**123**	43	53	106	153	178	96	97	116	106	137	114
Arsenic	mg/L	0.001	**0.002**	<0.001	0.002	0.002	0.003	0.002	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Cadmium	mg/L	0.0001	**0.0010**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	**0.002**	0.001	<0.001	0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.001	<0.001	<0.001
Iron	mg/L	0.05	**0.120**	0.65	0.55	0.10	<0.05	<0.05	0.10	0.08	0.06	0.05	<0.05	0.07
Lead	mg/L	0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.285**	0.148	0.630	0.711	0.114	0.346	0.688	0.262	0.402	0.116	0.386	0.238
Nickel	mg/L	0.001	**0.002**	0.004	0.003	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001	0.001
Zinc	mg/L	0.005	**0.050**	<0.005	0.007	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005
Ammonia as N	mg/L	0.01	**0.03**	0.03	0.01	0.01	0.04	0.02	0.03	0.02	0.03	0.03	<0.01	0.01
Nitrite as N	mg/L	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	**0.07**	0.03	0.04	<0.01	0.03	0.02	<0.01	0.02	<0.01	0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	**0.07**	0.03	0.04	<0.01	0.03	0.02	<0.01	0.02	<0.01	0.01	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	**1.7**	0.8	0.7	0.5	0.7	0.6	0.5	0.3	0.3	0.8	0.2	0.4
Total Nitrogen as N	mg/L	0.1	**0.7**	0.8	0.7	0.5	0.7	0.6	0.5	0.3	0.3	0.8	0.2	0.4
Total Phosphorus as P	mg/L	0.01	**0.20**	0.07	0.02	0.05	0.13	0.03	0.03	0.01	0.02	0.05	0.02	0.03
Ionic Balance	%	0.01	**1.84**	3.78	0.79	3.73	1.51	1.61		3.87	2.39	4.82	3.79	0.50
Total Anions	meq/L	0.01	**50.91**	5.21	10.2	14.8	15.2	10.4		8.49	11.4	8.74	14.6	11.8
Total Cations	meq/L	0.01	**13.83**	13.8	14.8	10.1				9.17	11.9	9.62	13.6	11.9

Parameter	17/10/2017	15/11/2017	12/12/2017	17/01/2018	15/02/2018	14/03/2018	18/04/2018	18/05/2018	18/06/2018	18/07/2018	16/08/2018	20/09/2018	20/09/2018	22/10/2018	14/11/2018
pH Value	7.8	7.80	7.4	7.8	7.5	7.5	7.5	7.6	7.7	7.6	7.9	7.6	7.6	7.8	7.8
Electrical Conductivity @ 25°C	1390	1400	718	1580	1780	1180	1050	1330	1410	1380	1430	1280	1290	1310	1750
Suspended Solids (SS)	6	11	6	10	10	10	6	3	2	3	8	5	5	10	10
Bicarbonate Alkalinity as CaCO3	478	501	172	406	427	235	297	419	440	399	444	331	333	415	490
Carbonate Alkalinity as CaCO3	<1	10	<1	<1	9	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	478	511	172	406	436	235	297	419	440	399	444	331	333	415	490
Sulfate as SO4 - Turbidimetric	75	115	58	215	252	232	109	117	123	134	150	114	116	85	204
Chloride	150	139	76	187	198	154	120	148	168	157	162	146	148	148	223
Calcium	76	77	35	93	97	60	55	75	80	77	81	68	67	68	108
Magnesium	48	48	24	51	55	49	41	51	50	47	47	44	44	44	57
Potassium	5	3	5	4	2	7	6	6	6	5	5	4	4	4	3
Sodium	156	171	64	189	226	116	101	145	151	149	151	127	124	136	209
Arsenic	0.001	0.001	0.002	0.002	0.002	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Cadmium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	<0.05	<0.05	0.53	<0.05	<0.05	0.11	0.18	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.09	<0.05
Lead	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	0.430	0.186	0.905	0.100	0.115	1.04	0.886	0.335	0.465	0.450	0.220	0.518	0.510	0.473	0.265
Nickel	0.001	<0.001	0.003	0.001	<0.001	0.004	0.002	0.002	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Zinc	<0.005	<0.005	0.009	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N	0.01	<0.01	0.06	<0.01	<0.01	0.01	0.01	<0.01	0.02	<0.01	<0.01	0.02	<0.01	0.06	0.03
Nitrite as N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	<0.01	<0.01	0.01	0.04	0.03	0.02	<0.01	0.02	0.01	0.02	<0.01	<0.01	0.02	0.03	0.07
Nitrite + Nitrate as N	<0.01	<0.01	0.01	0.04	0.03	0.02	<0.01	0.02	0.01	0.02	<0.01	<0.01	0.02	0.03	0.07
Total Kjeldahl Nitrogen as N	0.5	0.5	0.8	0.4	0.4	0.8	0.6	0.4	0.4	0.2	0.3	0.4	0.4	0.4	0.4
Total Nitrogen as N	0.5	0.5	0.8	0.4	0.4	0.8	0.6	0.4	0.4	0.2	0.3	0.4	0.4	0.4	0.5
Total Phosphorus as P	0.02	0.06	0.07	0.03	0.05	0.03	0.04	0.01	<0.01	<0.01	<0.01	0.02	0.02	0.02	0.04
Ionic Balance	2.29	3.82	1.15	2.00	0.76	6.19	4.15	1.98	4.08	2.95	6.28	1.80	3.04	4.41	2.73
Total Anions	15.3	16.5	6.79	17.9	19.5	13.9	11.6	15.0	16.1	15.2	16.6	13.1	13.2	14.2	20.3
Total Cations	14.6	15.3	6.63	17.2	19.2	12.2	10.7	14.4	14.8	14.3	14.6	12.6	12.5	13.0	19.2

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Table A2.9
Monitoring Results: Lawsons Creek (Downstream 1) BSW 20

				Sampling Date																						
Parameter	**Unit**	**LOR**	**Mean**	**19/07/2012**	**16/08/2012**	**14/09/2012**	**18/10/2012**	**21/11/2012**	**20/12/2012**	**19/02/2013**	**19/03/2013**	**16/04/2013**	**15/05/2013**	**25/06/2013**	**21/11/2013**	**18/02/2014**	**22/05/2014**	**20/08/2014**	**20/11/2014**	**9/02/2015**	**1/05/2015**	**14/08/2015**	**14/10/2015**	**12/05/2016**	**31/08/2016**	**26/09/2016**
pH Value	pH Unit	0.01	**7.9**	7.6	8	7.9	7.9	8	8	7.7	7.6	7.7	7.9	7.6	7.5	8.5	7	7.2	8.30	7.60	8.40	7	7.6	8.7	7.6	7.4
Electrical Conductivity @ 25°C	µS/cm	1	**1117**	550	780	940	1170	1250	1340	885	870	965	1050	1000	1400	2050	1200	1190	1540.00	1930	1900	1000	1350	1560	776	300
Suspended Solids (SS)	mg/L	1	**28**						15	17	6	5	13	24	0.08	92	79	11	72.00	71	103	6	34	14	10	12
Bicarbonate Alkalinity as CaCO3	mg/L	1	**215**							151	148	177	240	141	180	295	136	130	223.00	274.00	227.00	101	208	181	104	59
Carbonate Alkalinity as CaCO3	mg/L	1	**25**							<1	<1	<1	<1	<1	<1	21	<1	<1	<1	<1	<1	<1	<1	29	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1								<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**217**							151	148	177	240	141	12	316	136	130	223.00	274.00	227.00	101	208	210	104	59
Sulfate as SO4 - Turbidimetric	mg/L	1	**144**	90	143	146	195	190	112	152	148	121	109	164	212	219	247	194	225.00	234	274	210	246	195	136	34
Chloride	mg/L	1	**157**	60	97	138	195	180	214	101	103	112	126	126	222	351	151	193	298.00	348	376	104	167	280	104	28
Calcium	mg/L	1	**46**	22	31	37	50	59	58	38	38	48	53	40	39	62	61	46	40.00	60.00	54.00	48	75	34	30	13
Magnesium	mg/L	1	**50**	26	39	48	58	65	59	42	42	44	47	44	61	93	57	50	74.00	85	92	45	63	76	37	12
Potassium	mg/L	1	**6**	4	3	4	5	5	6	6	5	5	8	5	8	10	8	5	5.00	9	15	5	6	11	5	3
Sodium	mg/L	1	**115**	45	66	84	120	133	<0.001	85	88	104	98	92	151	277	116	129	187.00	232.00	244.00	106	129	190	68	28
Arsenic	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.001	0.001	<0.001	<0.001	<0.001	0.001	0.006	<0.001	<0.001	0.00	0.005	0.003	<0.001	<0.001	0.002	<0.001	<0.001
Cadmium	mg/L	0.0001	**0.0001**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.002**							<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	0.00	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	**0.002**	<0.001	0.001	<0.001	0.001	0.003	<0.001	0.002	0.002	<0.001	0.003	0.002	0.006	0.002	0.002	0.002	<0.001	0.005	0.004	0.002	<0.001	0.002	0.001	0.002
Iron	mg/L	0.05	**0.159**	0.33	0.17	0.06	0.07	<0.05	0.05	<0.05	0.08	<0.05	0.1	0.12	<0.05	<0.05	<0.05	<0.05	0.06	0.09	0.67	0.06	<0.05	0.06	0.16	0.55
Lead	mg/L	0.001	**0.003**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.379**	0.154	0.211	0.472	0.599	0.325	0.505	0.544	0.312	0.221	0.373	0.249	<0.001	0.082	0.545	0.348	0.35	0.99	0.61	0.244	1.38	0.016	0.167	0.088
Nickel	mg/L	0.001	**0.003**	0.002	0.002	0.002	0.003	0.002	<0.001	0.003	0.003	0.001	0.002	0.001	0.003	0.002	0.003	0.002	0.00	0.005	0.005	0.002	0.002	0.003	0.003	0.006
Zinc	mg/L	0.005	**0.020**	<0.005	<0.005	<0.005	0.013	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.02	0.011	<0.005	0.008	0.016	<0.005	0.109	0.014	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N	mg/L	0.01	**0.03**							<0.01	<0.01	<0.01	<0.01	0.02	0.06	0.09	0.05	0.02	0.04	0.05	0.03	0.02	0.01	0.01	0.01	0.01
Nitrite as N	mg/L	0.01	**0.01**							<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	**0.03**							0.05	0.03	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.05	<0.01	<0.01	0.02	<0.01	0.03	<0.01	0.02	0.03
Nitrite + Nitrate as N	mg/L	0.01	**0.03**							0.05	0.03	<0.01	<0.01	<0.01	0.01	0.02	0.01	0.05	<0.01	<0.01	0.02	<0.01	0.03	<0.01	0.02	0.03
Total Kjeldahl Nitrogen as N	mg/L	0.1	**1.4**							0.9	1.5	0.4	0.9	0.7	13.7	2	1	0.6	1.30	2.1	2.4	0.4	0.7	1.1	0.7	1.2
Total Nitrogen as N	mg/L	0.1	**1.1**							1	1.5	0.4	0.9	0.7	1.6	2	1	0.6	1.30	2.10	2.40	0.4	0.7	1.1	0.7	1.2
Total Phosphorus as P	mg/L	0.01	**0.13**							0.06	0.37	<0.01	0.06	0.03	1.6	0.12	0.06	0.04	0.06	0.11	0.16	0.01	0.06	0.06	0.03	0.11
Ionic Balance	%	0.01	**3.47**							0.93	1.98	4.05	1.66	0.21	1.92	5.18	3.44	0.27	3.55	0.35	0.97		16.5	1.4		5.01
Total Anions	meq/L	0.01	**16.68**							9.03	8.94	9.83	10.6	9.79	180	20.8	12.1	12.1	17.60	20.20	20.80		7.63	7.84	2.68	5.12
Total Cations	meq/L	0.01	**11.69**							9.2	9.31	10.7	11	9.75	14.3	23	13	12.2	16.40	20.30	21.30			2.93	5.66	5.11

Table A2.9 (Cont'd)
Monitoring Results: Lawsons Creek (Downstream 1) BSW 20

			Sampling Date																						
Parameter	**Unit**	**LOR**	**Mean**	**26/10/2016**	**21/11/2016**	**12/12/2016**	**20/01/2017**	**16/02/2017**	**14/03/2017**	**22/08/2017**	**20/09/2017**	**17/10/2017**	**14/11/2017**	**13/12/2017**	**16/01/2018**	**16/02/2018**	**14/03/2018**	**18/04/2018**	**18/05/2018**	**18/06/2018**	**18/07/2018**	**16/08/2018**	**20/09/2018**	**22/10/2018**	**14/11/2018**
pH Value	pH Unit	0.01	**7.9**	7.7	7.6	7.9	8.4	8.8	8.4	8	7.9	7.9	8.3	7.8	8.7	8.7	7.5	7.6	7.7	7.7	7.9	7.9	7.9	7.9	8.1
Electrical Conductivity @ 25°C	µS/cm	1	**1117**	533	531	716	1180	1230	1350	988	1080	1200	1230	845	1130	1320	1120	1010	1120	1150	1070	1130	1100	1100	1190
Suspended Solids (SS)	mg/L	1	**28**	10	15	9	35	70	57	11	18	19	26	7	18	32	20	14	16	28	10	14	20	14	28
Bicarbonate Alkalinity as CaCO3	mg/L	1	**215**	99	124	227	306	251	309	252	272	351	325	221	293	318	202	216	260	287	239	282	257	290	363
Carbonate Alkalinity as CaCO3	mg/L	1	**25**	<1	<1	<1	21	32	4	<1	<1	4	31	<1	40	40	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	**217**	99	124	227	326	283	313	252	272	355	356	221	333	358	202	216	260	287	239	282	257	290	363
Sulfate as SO4 - Turbidimetric	mg/L	1	**144**	71	48	66	105	102	120	81	90	100	125	81	68	65	231	147	149	125	129	129	90	81	88
Chloride	mg/L	1	**157**	59	48	78	140	167	189	106	111	156	149	104	152	188	160	128	142	156	141	161	142	149	169
Calcium	mg/L	1	**46**	23	23	33	54	40	49	49	55	60	61	45	48	41	52	48	52	60	52	56	49	52	60
Magnesium	mg/L	1	**50**	28	24	37	54	56	60	38	48	48	48	38	49	52	50	45	44	47	45	44	43	43	48
Potassium	mg/L	1	**6**	3	3	4	5	5	6	6	7	7	5	5	5	6	8	7	5	8	5	5	5	4	4
Sodium	mg/L	1	**115**	49	44	68	112	132	144	80	95	119	128	78	125	168	101	92	95	107	96	103	100	102	120
Arsenic	mg/L	0.001	**0.002**	<0.001	0.001	0.002	0.003	0.004	0.002	<0.001	0.001	0.001	<0.001	<0.001	0.004	0.006	0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.002
Cadmium	mg/L	0.0001	**0.0001**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	**0.002**	0.002	0.002	0.005	<0.001	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.003	0.002	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Iron	mg/L	0.05	**0.159**	0.46	0.26	0.05	<0.05	<0.05	<0.05	0.08	<0.05	<0.05	<0.05	0.19	0.06	0.08	0.06	0.06	<0.05	0.16	0.05	<0.05	<0.05	<0.05	<0.05
Lead	mg/L	0.001	**0.003**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.379**	0.256	0.449	0.167	0.309	0.286	0.224	0.332	0.442	0.452	0.013	0.806	0.308	0.309	0.246	0.402	0.296	0.77	0.315	0.741	0.336	0.491	0.560
Nickel	mg/L	0.001	**0.003**	0.004	0.005	0.002	0.002	0.003	0.003	0.002	0.003	0.002	0.002	0.002	0.002	0.003	0.004	0.002	0.002	0.002	0.001	0.002	0.002	0.001	0.002
Zinc	mg/L	0.005	**0.020**	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	0.006	<0.005	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N	mg/L	0.01	**0.03**	0.02	0.02	<0.01	0.02	<0.01	0.02	0.02	0.03	0.01	0.02	<0.01	<0.01	0.02	<0.01	0.03	<0.01	0.01	<0.01	<0.01	0.01	0.06	0.02
Nitrite as N	mg/L	0.01	**0.01**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
Nitrate as N	mg/L	0.01	**0.03**	<0.01	0.03	<0.01	0.03	<0.01	0.02	0.07	0.01	<0.01	<0.01	<0.01	0.02	0.07	0.04	<0.01	0.03	0.01	0.02	0.02	<0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	**0.03**	<0.01	0.03	<0.01	0.03	<0.01	0.02	0.07	0.01	<0.01	<0.01	<0.01	0.02	0.07	0.04	<0.01	0.03	0.01	0.02	0.02	<0.01	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	**1.4**	2.3	1	0.8	1.3	3	1.6	0.6	0.8	0.6	0.8	0.6	1	1.6	0.6	0.8	0.6	0.4	0.6	0.4	0.6	0.4	0.7
Total Nitrogen as N	mg/L	0.1	**1.1**	2.3	1	0.8	1.3	3	1.6	0.7	0.8	0.6	0.8	0.6	1	1.7	0.6	0.8	0.6	0.4	0.6	0.4	0.6	0.4	0.7
Total Phosphorus as P	mg/L	0.01	**0.13**	0.05	0.05	0.03	0.11	0.2	0.11	0.03	0.22	0.03	0.08	0.03	0.08	0.17	0.05	0.05	0.02	<0.01	0.06	0.01	0.03	<0.01	0.03
Ionic Balance	%	0.01	**3.47**	2.84	2.26	2.06	0.06	14.1	1.02	2.67	2.64	4.93	4.62	0.79	1.49	0.08	8.31	3.32	8.02	4.15	3.79	7.69	2.57	4.52	6.07
Total Anions	meq/L	0.01	**16.68**	4.83	8.11	12.6	12.5	13.8		9.71	10.4	13.6	13.9	9.04	12.4	13.8	13.4	11	12.3	12.7	11.4	12.9	11.0	11.7	13.8
Total Cations	meq/L	0.01	**11.69**	7.75	12.1	12.5				9.2	11	12.3	12.7	8.89	12	13.8	11.3	10.3	10.5	11.7	10.6	11.0	10.5	10.7	12.3

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Annexure B

Flood Impact Assessment

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Bowdens Silver Project

Flood Impact Assessment

Bowdens Silver Pty Limited

1356-01-O5, 31 January 2020

Report Title	Bowdens Silver Project Flood Impact Assessment
Client	Bowdens Silver Pty Ltd C/- R.W. Corkery and Co. Pty Limited
Report Number	1356-01-O5

Revision Number	Report Date	Report Author	Reviewer
5	31 January 2020	AN	MB

For and on behalf of WRM Water & Environment Pty Ltd
Level 9, 135 Wickham Tce, Spring Hill
PO Box 10703 Brisbane Adelaide St Qld 4000
Tel 07 3225 0200

Michael Batchelor
Director

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1 Introduction

1.1 BACKGROUND

Bowdens Silver Pty Ltd (Bowdens Silver) is seeking approval to develop and operate an open cut silver mine near Lue, NSW (the Project). The Mine Site is located approximately 26 km east of Mudgee, NSW and is currently an undeveloped site. Figure 1.1 shows the location of the Mine Site.

Bowdens Silver requested WRM Water and Environment Pty Ltd (WRM) undertake a surface water assessment forming part of the Environmental Impact Statement for the Project. In accordance with the Secretary's Environmental Assessment Requirements, the impact assessment includes a detailed assessment of flooding on the Mine Site, and potential the impact of the proposed works on flooding in the adjacent reaches of Lawsons Creek, Hawkins Creek and their tributaries.

This report presents the methodology and results of hydrologic and hydraulic modelling undertaken for this assessment across.

1.2 PROJECT DESCRIPTION

Figure 1.2 shows the proposed Mine Site layout. The proposed operations would involve a conventional open cut mine including an out-of-pit waste rock emplacement (WRE), processing plant (with concentrate storage), tailings storage facility (TSF) and other ancillary infrastructure.

The Project would also involve construction of a new access road providing access to the Mine Site from a point west of Lue. The new access road would cross Lawsons Creek and effectively replace approximately 4.5km of Maloneys Road (Pyangle Road) that would be closed once the new road is constructed.

The study area for this assessment comprises the Mine Site and the adjacent reaches of Lawsons Creek, Hawkins Creek and their tributaries, including the reach of Lawsons Creek in the vicinity of the relocated Maloneys Road crossing.

1.3 REPORT STRUCTURE

This report is structured as follows.

- Section 2 - describes the existing drainage characteristics in the vicinity of the Mine Site;
- Section 3 - describes the infrastructure proposed for the Project which could potentially impact on flooding;
- Section 4 - describes the development of the hydrologic model used to estimate design peak discharges, including the model validation process;
- Section 5 - describes the methodology used to estimate the design discharges, and presents the design peak discharges at some key locations;
- Section 6 - describes the development of the hydraulic model used to estimate design peak flood levels and velocities in the vicinity of the Mine Site, and includes some flood mapping;
- Section 7 - describes the hydraulic modelling undertake used to estimate design flood conditions during Project operations and post-closure, including mapping of the impact of the proposed works on design flood levels and velocities;
- Section 8 - provides a summary of findings; and
- Section 9 - provides a list of references.

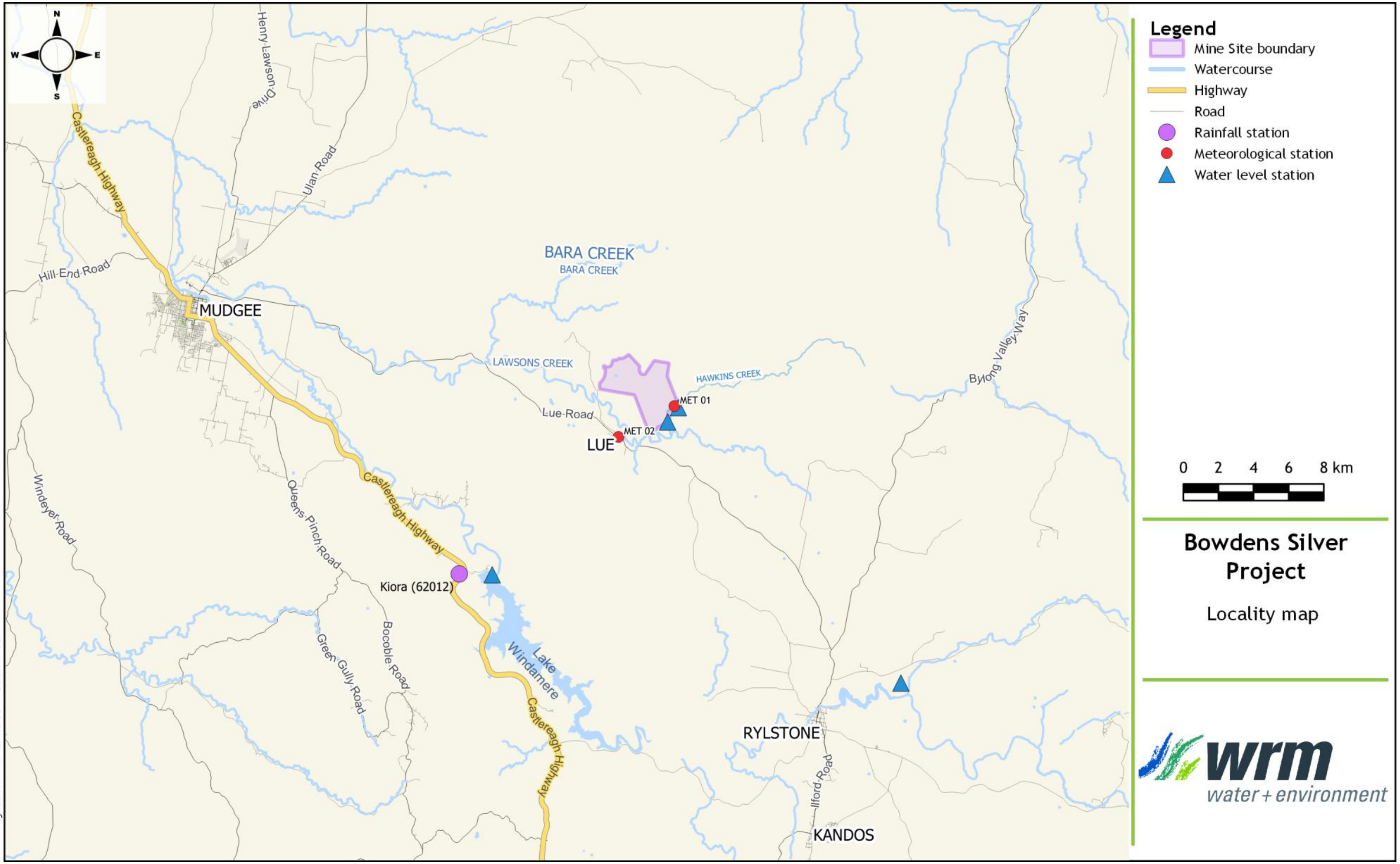


Figure 1.1 – Locality

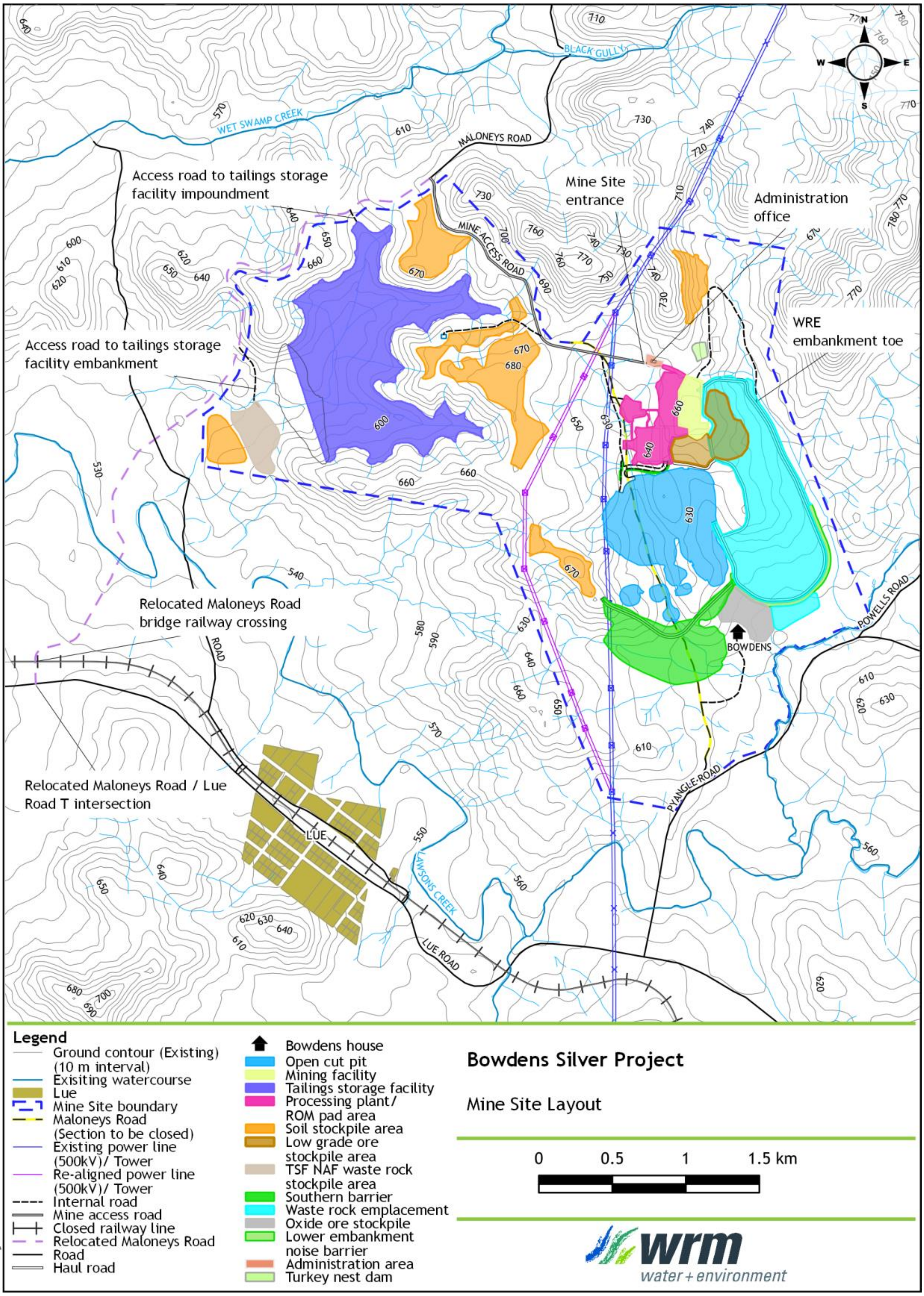


Figure 1.2 – Proposed layout of the Project

2 Existing drainage characteristics

2.1 REGIONAL DRAINAGE

Figure 2.1 shows the regional drainage features in the vicinity of the Mine Site which is located within the Lawsons Creek catchment, in the eastern headwaters of the Macquarie River basin. Lawsons Creek flows in a northwesterly direction and drains to the Cudgegong River near the township of Mudgee. The Cudgegong River flows in in a northwesterly direction from Mudgee, before turning to the southwest and eventually draining to Burrendong Dam. Lawsons Creek has a catchment area of approximately 507 km^2 to the Cudgegong River confluence (near Mudgee). Burrendong Dam has catchment area of approximately 13,900 km^2.

2.2 LOCAL DRAINAGE

Figure 2.2 shows the Lawsons Creek catchment to just downstream of Lue. Figure 2.3 shows the local drainage characteristics within and in the immediate vicinity of the Mine Site boundary.

Hawkins Creek, a tributary of Lawsons Creek, flows in a southwesterly direction adjacent to but beyond the southeastern boundary of the Mine Site. Hawkins Creek has a catchment area of 61 km^2 upstream of the confluence with Lawsons Creek.

The Mine Site is traversed by the following tributaries of Hawkins and Lawsons Creeks (refer to Figure 2.3 for their locations):

- Price Creek (a south-flowing tributary of Hawkins Creek), which has a catchment area of 5.2 km^2 upstream of the Hawkins Creek confluence;
- Blackmans Gully (a south-flowing tributary of Hawkins Creek), which has a catchment area of 2.3 km^2 upstream of its confluence with an unnamed east-flowing tributary (referred to as the UN South tributary - catchment area of 1.1 km^2). Its downstream reach (referred to as Blackmans Gully DS) has a catchment area of 3.6 km^2 to its confluence with Hawkins Creek.
- an unnamed south-flowing tributary of Hawkins Creek, referred to as the UN East tributary, which has a catchment area of 0.9 km^2 upstream of the Hawkins Creek confluence;
- an unnamed west-flowing tributary of Lawsons Creek, referred to as the UN West tributary, which has a catchment area of 1.6 km^2 upstream of the Lawsons Creek confluence; and
- Walkers Creek (a west-flowing tributary of Lawsons Creek) which has a catchment area of 4.8 km^2 upstream of the Lawsons Creek confluence. The Walkers Creek catchment is the site of the proposed tailings storage facility (TSF).

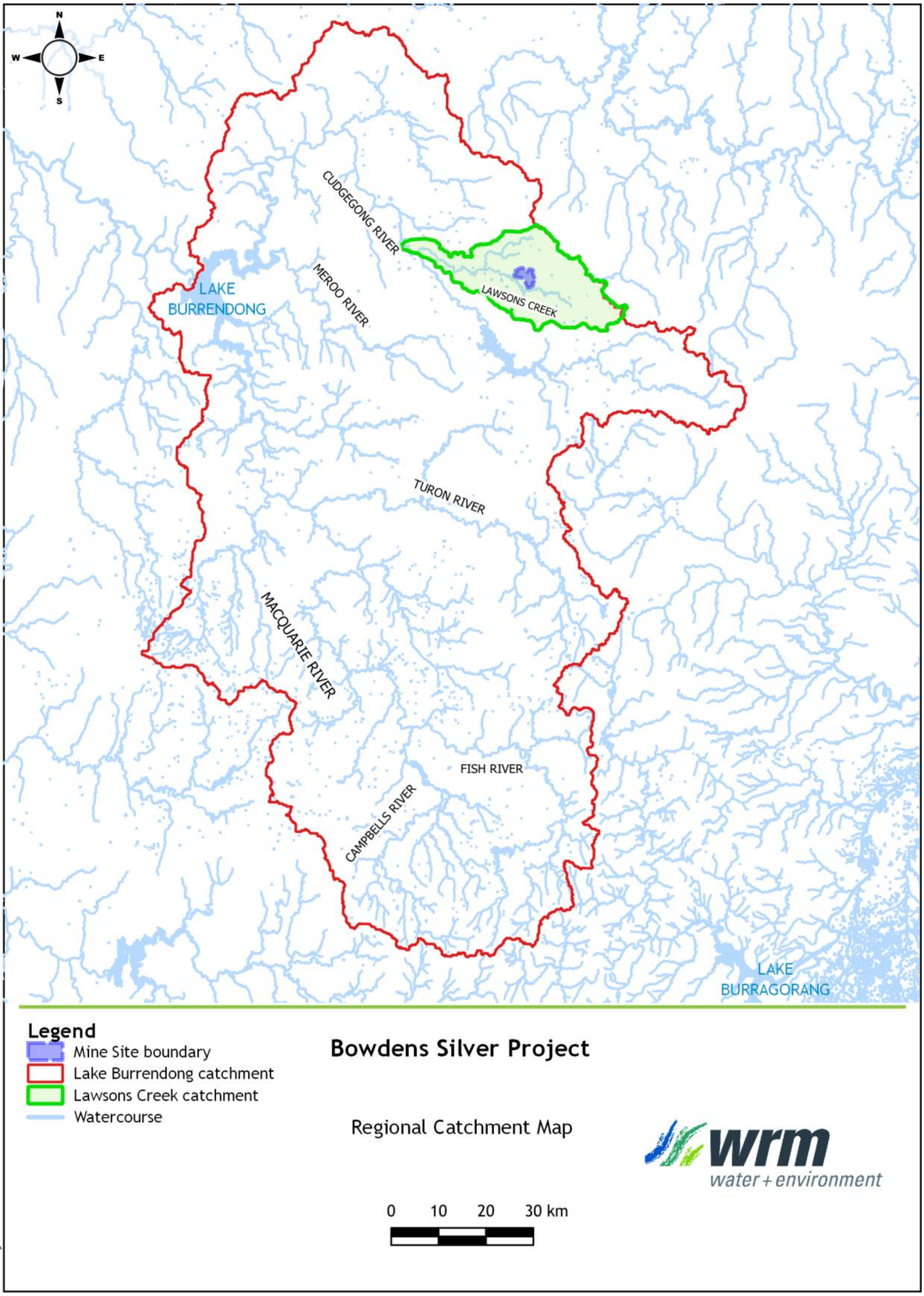


Figure 2.1 – Regional drainage features

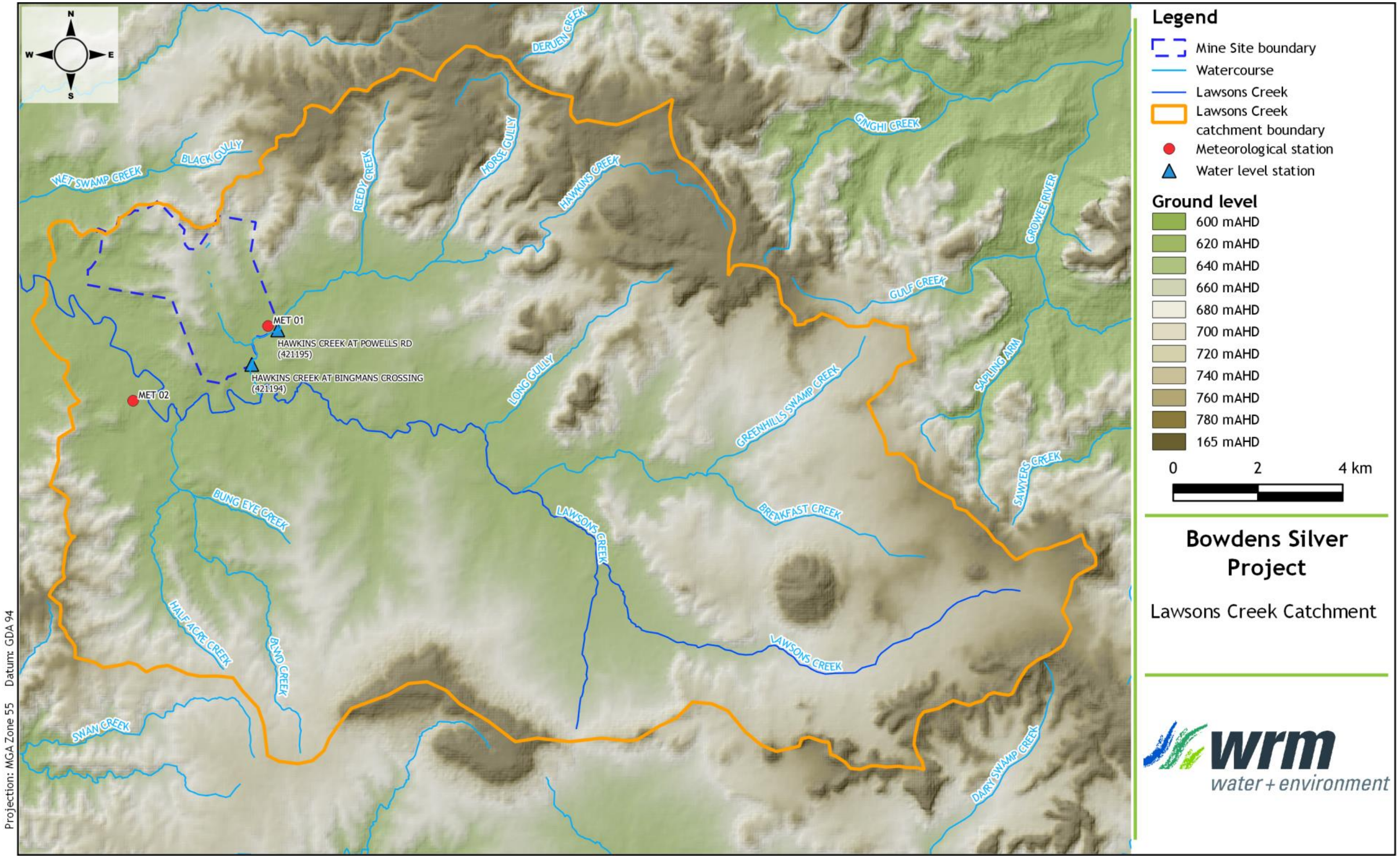


Figure 2.2 - Lawsons Creek catchment and the locations of rainfall and water level recording stations operated by Bowdens Silver

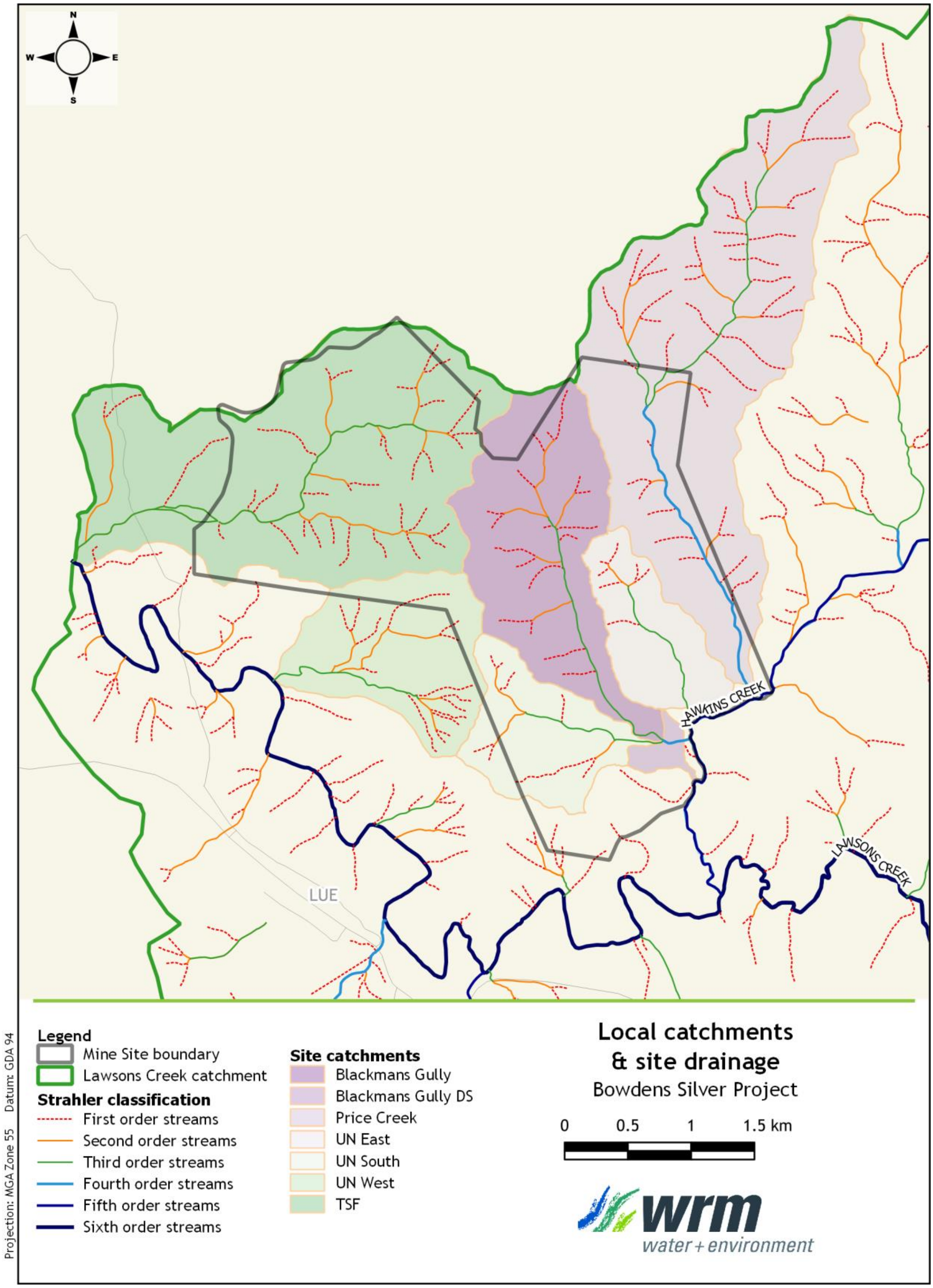


Figure 2.3 – Local drainage features

3 Description of proposed infrastructure

3.1 OVERVIEW

The proposed site layout is described in detail in the project description (EIS Section 2) as shown in Figure 1.2. Proposed infrastructure which could potentially interact with flood flow paths include the following:

- Waste rock emplacement (and associated haul roads and noise barriers);
- Leachate management dam;
- Southern barrier;
- Relocated Maloneys Road (Pyangle Road) crossing of Lawsons Creek;
- Clean water diversion system from Blackmans Gully to Price Creek.

The footprint of the proposed works would be largest during site operations. At the completion of mining and following rehabilitation of the Mine Site, some of these works would be decommissioned. As a result, the assessment has been based on two scenarios - maximum disturbance, and post-closure. Further details of how the works are incorporated into the flood model are provided in section 6.

3.2 WASTE ROCK EMPLACEMENT

The waste rock emplacement (WRE) is proposed to be constructed immediately to the east of the main open cut pit. The emplacement would be constructed in stages from north to south and includes a leachate collection system, lower haul road, and noise barrier along its eastern toe. The lower haul road and noise barrier would be decommissioned post-mining.

These works have the potential to impact flood conditions on the western margin of the Price Creek floodplain, and would interact with existing contour banks and other drainage structures within Price Creek. For the purpose of this assessment, the impacts of the proposed works in conjunction with existing structures has been assessed. During detailed design of the waste rock emplacement, consideration would be given to the mitigation of these impacts in conjunction with the decommissioning of existing drainage works.

3.3 SOUTHERN BARRIER

The southern barrier would be constructed across Blackmans Gully, and during operations would largely control flood flows entering Lawsons Creek downstream as flows would be directed through a culvert beneath the barrier. Runoff from nearby local stormwater catchments would be directed around the toe of the southern barrier. The Southern barrier would be decommissioned post-mining, and the pre-mine flow paths would be re-instated.

3.4 BLACKMANS GULLY CLEAN WATER DIVERSION DRAIN

The upper part of the Blackmans Gully catchment would be diverted east to Prices Creek, to reduce the potential for clean water to enter the active main open cut pits. The effect of this channel has been modelled by relocating the modelled upper sub-catchment inflows to Price Creek instead of Blackmans Gully.

3.5 LEACHATE MANAGEMENT DAM

The proposed leachate management dam would be located on the margin of the Lawsons Creek floodplain. The potential effect of this structure on the Lawsons Creek flooding and local runoff from Prices Creek has been assessed by incorporating the design surface into the hydraulic model.

3.6 LAWSONS CREEK CROSSING

The proposed Lawsons Creek crossing would be designed to be overtopped by flows in Lawsons Creek during a 10% (1 in 10) AEP event. Figure 3.1 shows the cross section of the proposed configuration used in the model. The following design characteristics have been adopted (however, the configuration would be refined further during detailed design):

- A road crest level of 528.8 mAHD (the existing 1 in 10 AEP flood level);
- A road width of 7 m;
- A two-way cross fall of 3%; and
- A road embankment (cut and fill) slope of 1V:3H;
- 10 barrels of 2.7 m (L) x 2.4 m RCBCs.

Based on the above assumptions, the road embankment would have a maximum height of 5 m above the creek bed, with the outer embankment slopes extending up to 17 m upstream and 15 m downstream of the road as shown in Figure 6.12.

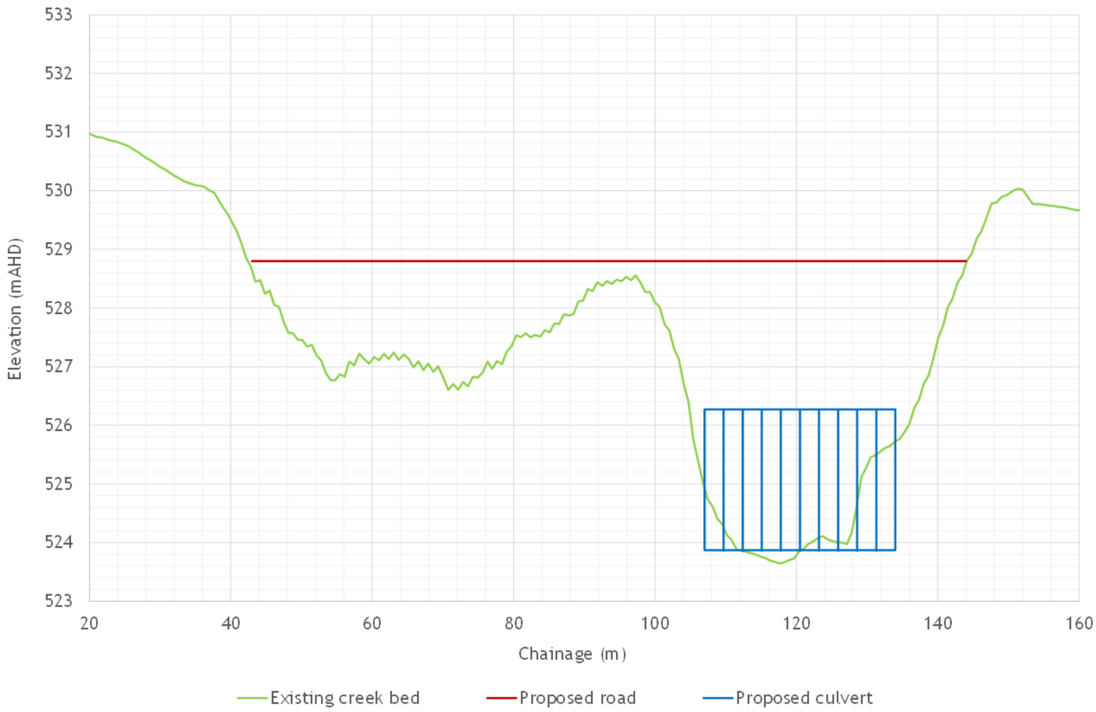


Figure 3.1 – Cross-section of proposed Lawsons Creek crossing (looking downstream)

4 Hydrologic model development and validation

4.1 METHODOLOGY

The XP-RAFTS runoff-routing model (Innovyze, 2018) was developed for the catchment of Lawsons Creek and its tributaries including Hawkins Creek and Price Creek.

The XP-RAFTS model was validated against Hawkins Creek water level data recorded by Bowdens Silver during three historical flow events (the validation events) peaking at the following dates:

- 20 July 2016 (July 2016 flow event);
- 9 September 2016 (September 2016 1st flow event); and
- 18 September 2016 (September 2016 2nd flow event).

None of these events were large floods in Hawkins Creek, with the largest having an AEP greater than 40%, and resulting in water just overtopping the banks. As a result, the data was unsuitable for calibration of the model, but was used to validate the adopted parameters.

4.2 AVAILABLE DATA

4.2.1 Rainfall data

There are no BOM-operated pluviometer stations located within Lawsons Creek catchment upstream of the Mine Site. Bowdens Silver operates the two meteorological stations adjacent to the Project, referred to as Stations MET01 and MET02. Figure 2.2 shows the locations of these meteorological stations.

Sub-hourly rainfall data recorded at MET01 and MET02 was available for the three validation events. However, given the large size of the Lawsons Creek catchment and the location of the rainfall station near the catchment outlet, it is possible that the rainfall data is not representative of rainfall over the entire catchment during these events.

Figure 4.1, Figure 4.2 and Figure 4.3 show the recorded rainfall intensities (mm/h) during the July 2016, September 2016 (1st flow event) and September 2016 (2nd flow event) respectively. Table 4.1 shows a summary of total rainfall depths recorded during the three validation events. For comparison, Table 4.1 also shows total rainfall depths recorded during three other smaller events which occurred between November 2016 and March 2017.

4.2.2 Streamflow data

There are no NSW Office of Water (NOW) or Bureau of Meteorology (BOM) streamflow recording stations in the vicinity of the Mine Site which would be suitable for model calibration.

Bowdens Silver provided streamflow records for Hawkins Creek at the following two recording stations it operates adjacent to the Project:

- Powells Road (Station No. 421195) - 3.2 year period from 26 March 2014 to 30 May 2017; and
- Bingmans Crossing (Station No. 421194) - 4 year period from 16 June 2013 to 30 May 2017.

Figure 2.2 shows the locations of these stations. These stations comprise a v-notch weir mounted on a concrete weir crossing the bottom of the channel. The invert level of the v-notch weir is at 0.5 m gauge height (GH) at both stations.

Figure 4.4 shows recorded water levels in Hawkins Creek at the Bingmans Crossing station (Station No. 421194) over the period of record. The period of record spans a period of very wet weather commencing in July 2016, preceded by a period of very dry weather. Figure 4.4 shows that baseflow generated depths of more than 100 mm over the v-notch weir between July and November 2016, and flow peaks exceeding 1 m gauge height (0.5 m above the v-notch weir crest) occurred several times over this period.

Figure 4.1, Figure 4.2 and Figure 4.3 show the recorded water level hydrographs during the July 2016, September 2016 (1st flow event) and September 2016 (2nd flow event) respectively. Table 4.1 shows a summary of recorded peak water levels at both stations during the three validation events, as well as the three smaller events between November 2016 and March 2017.

Figure 4.4 shows recorded water levels in Hawkins Creek at the Bingmans Crossing station (Station No. 421194) over the period of record. The period of record spans a period of very wet weather commencing in July 2016, preceded by a period of very dry weather. Figure 4.4 shows that baseflow generated depths of more than 100 mm over the v-notch weir between July and November 2016, and flow peaks exceeding 1 m gauge height (0.5 m above the v-notch weir crest) occurred several times during this period.

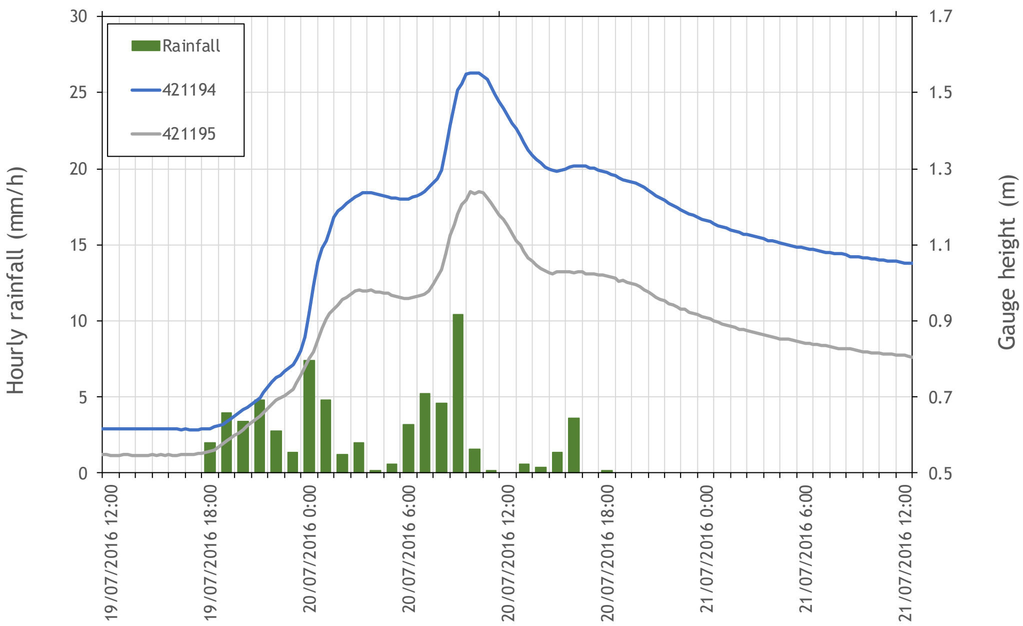


Figure 4.1 – Recorded water levels and rainfall intensities - July 2016 flow event

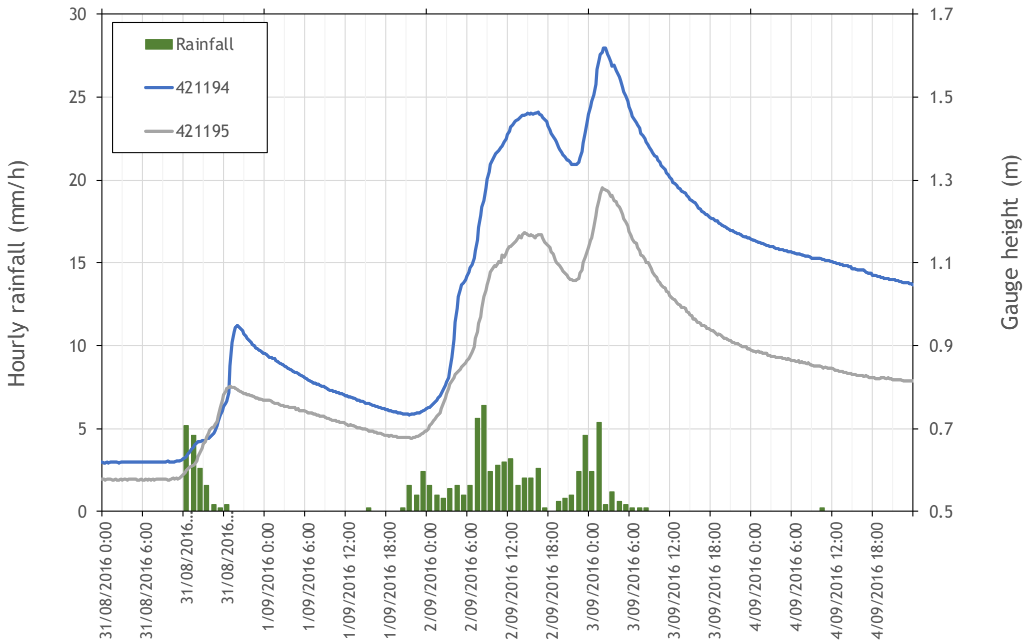


Figure 4.2 – Recorded water levels and rainfall - September 2016 1st flow event

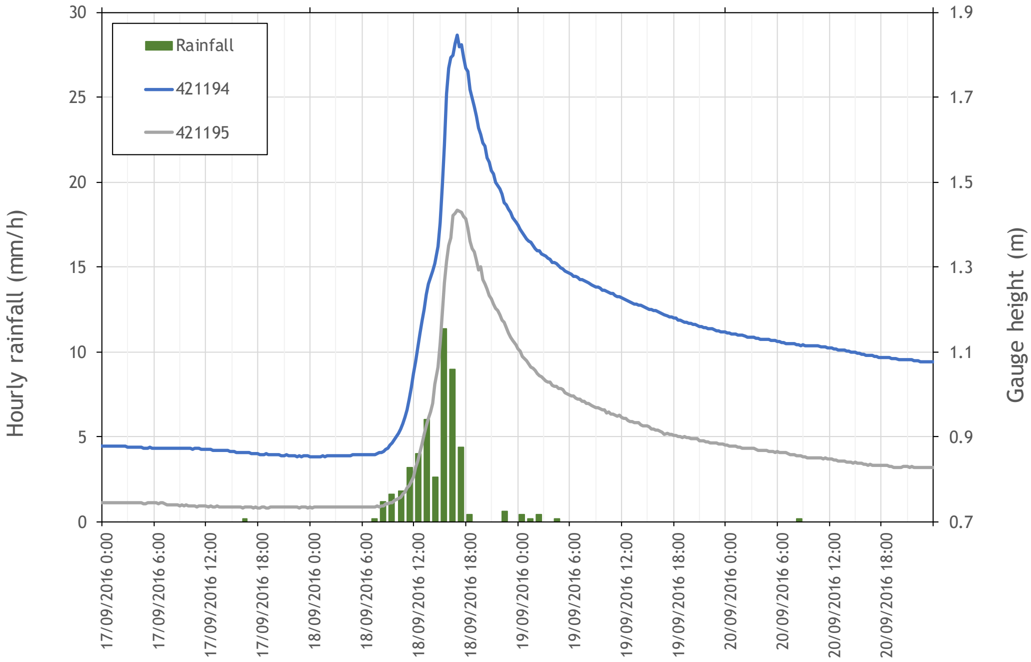


Figure 4.3 – Recorded water levels and rainfall - September 2016 2nd flow event

Table 4.1 – Summary of recorded rainfall depths and peak water levels at recording the stations operated by Bowdens Silver

Flow event	Event start date	Event finish date	Peak gauge height (m GH)		Total event rainfall depth (mm)	
			Bingmans Crossing (Stn. 421194)	Powells Road (Stn. 421195)	Station MET01	Station MET02
July 2016	19/07/2016	21/07/2016	1.55	1.24	66.0	64.6
September 2016 (1st flow event)	31/08/2016	9/09/2016	1.62	1.28	82.0	89.8
September 2016 (2nd flow event)	18/09/2016	20/09/2016	1.85	1.68	47.6	51.0
November 2016	12/11/2016	13/11/2016	1.22	0.96	49.2	56.0
March 2017 (1st flow event)	23/03/2017	25/03/2017	1.09	0.86	44.6	41.8
March 2017 (2nd flow event)	30/03/2017	1/04/2017	1.18	0.93	43.4	52.0

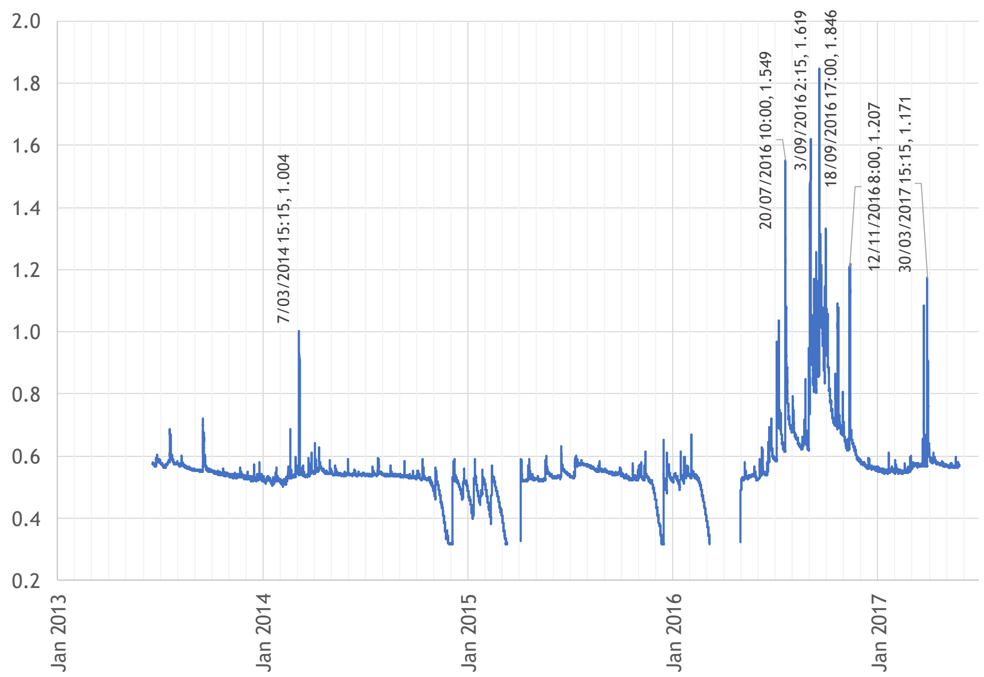


Figure 4.4 – Recorded water levels in Hawkins Creek at Bingmans Crossing (421194)

4.2.3 Rating curves

Bowdens Silver supplied rating curves (depth-vs-flow relationships) for the two Hawkins Creek recording stations. It is understood that these curves were developed from theoretical rating relationships and not from flow gaugings.

To validate the supplied rating curves, theoretical rating curves were developed by applying the theoretical relationships for v-notch weirs based on the dimensions measured during the site visit. The results showed that the theoretical rating curves closely matched the supplied rating curves.

The supplied rating curves do not extend to the range of flows occurring during high flow conditions. Therefore, the supplied rating curves were extrapolated by applying the following methodology:

- For flows up to 0.2 m^3/s (200 L/s), the rating curve were extracted from the original (supplied) rating curves.
- For high flows (greater than approximately 20 m^3/s), the rating curve was extracted from the TUFLOW hydraulic model results. The TULOW hydraulic model developed for this study is described in Section 6.
- For flows between approximately 0.2 m^3/s and 20 m^3/s, the rating curve was extracted from local HEC-RAS hydraulic models developed for each station. The HEC-RAS model for each station was developed using detailed ground survey of the creek and weir cross sections supplied by Bowdens Silver.

Figure 4.5 and Figure 4.6 show the rating curves described above for the Powells Road (421195) and Bingmans Crossing (421194) stations respectively. Figure 4.7 shows the adopted rating curves for both stations.

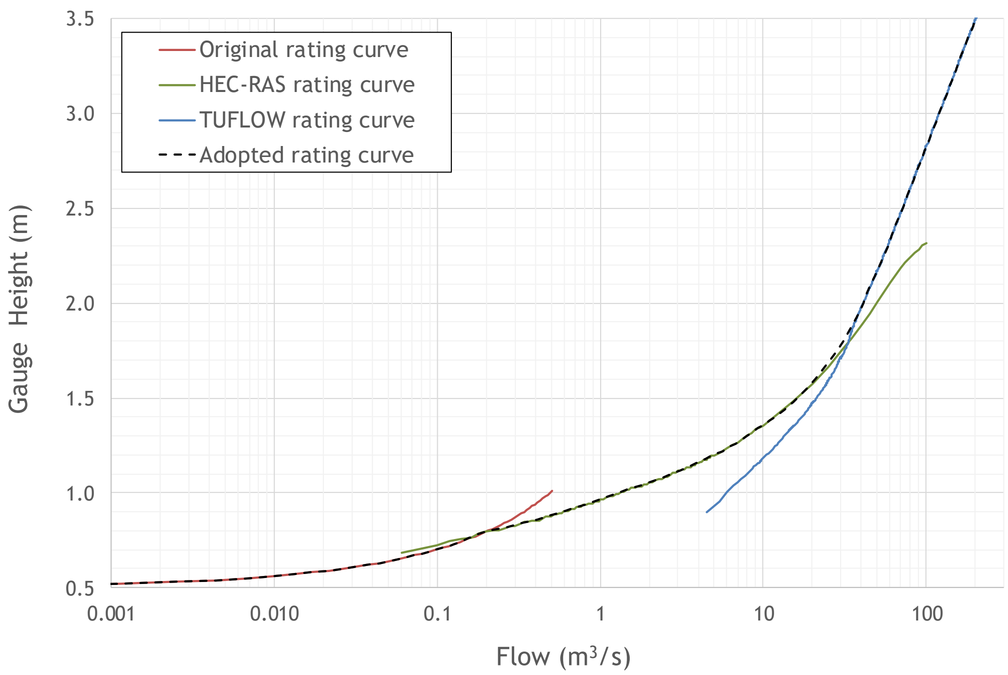


Figure 4.5 – Derivation of rating curve for Bowdens Silver recording station: Hawkins Creek at Powells Road (421195)

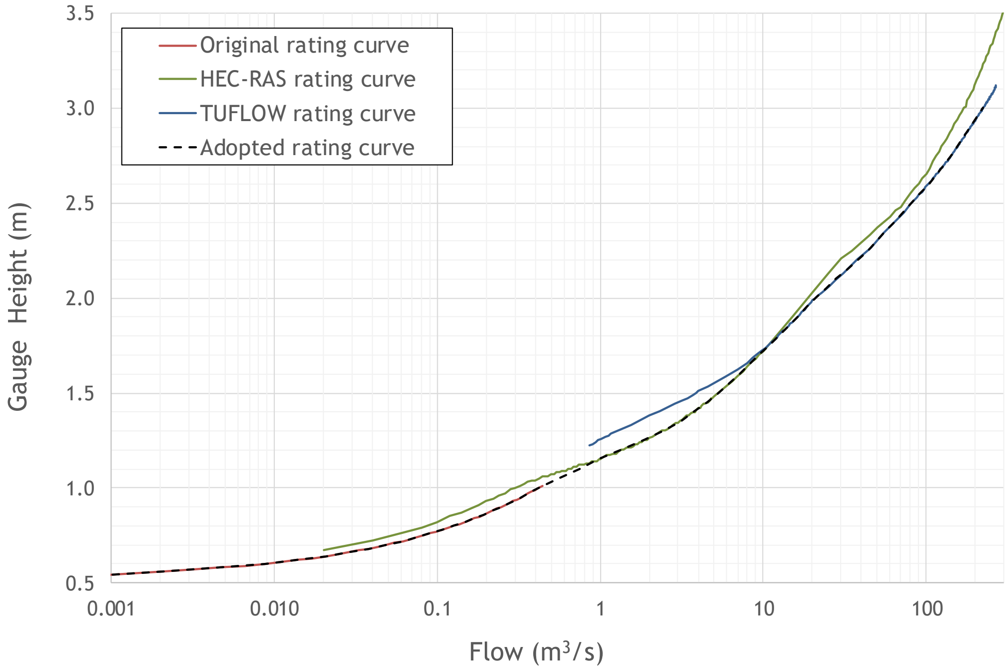


Figure 4.6 – Derivation of rating curve for Bowdens Silver recording station: Hawkins Creek at Bingmans Crossing (421194)

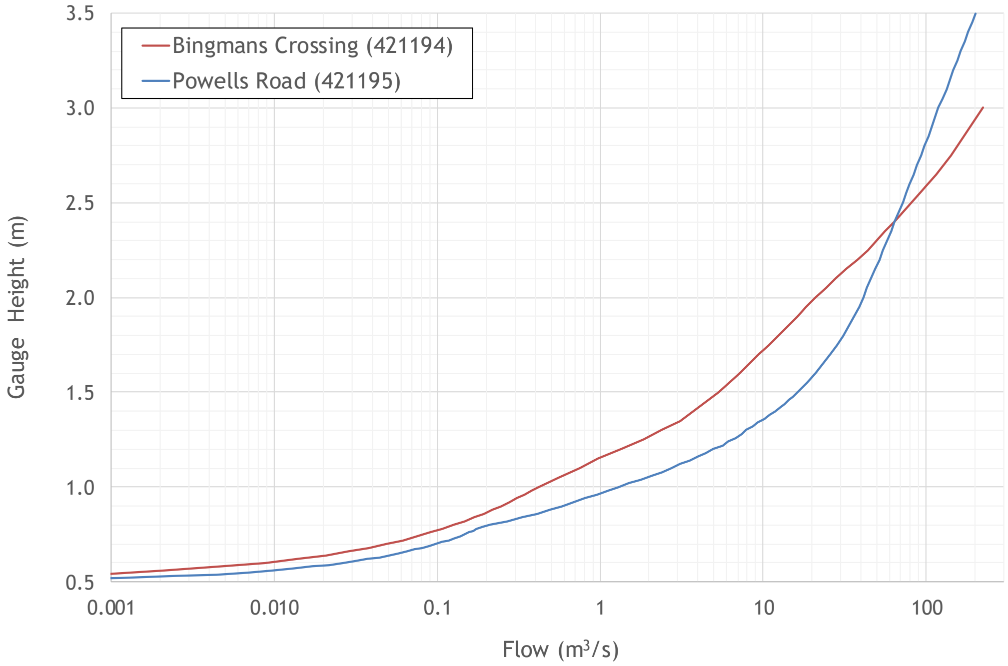


Figure 4.7 – Adopted rating curves for Bowdens Silver re-coding stations on Hawkins Creek

4.3 XP-RAFTS MODEL CONFIGURATION

4.3.1 Model extent

Figure 4.8 shows the entire XP-RAFTS model layout. Figure 4.9 shows the XP-RAFTS model subcatchments within the Project. The model extends to downstream of the confluence of Lawsons Creek and the TSF tributary. The total catchment of the XP-RAFTS model to the outlet is 272 km^2. The model has been subdivided into 84 subcatchments.

4.3.2 Subcatchment parameters

The adopted XP-RAFTS subcatchment parameters were configured based on the available topographic data and aerial photographs. Table A.1 in Appendix A shows the adopted subcatchment parameters including catchment area, percentage impervious, catchment slope and PERN 'n' catchment roughness coefficients. Model parameters for each subcatchment were determined as follows:

- A percentage impervious of zero was adopted for all subcatchments.
- Catchment slopes were determined based on the available topographic data.
- A default subcatchment storage coefficient multiplication factor 'Bx' of 1.0 was adopted for all events, and validated against the recorded catchment response.
- Subcatchment PERN 'n' values were determined based on the density of vegetation in each subcatchment. The adopted subcatchment PERN 'n' values are:
  - 0.035 for subcatchments with grassed areas;
  - 0.040 for subcatchments with a mixture of grassed and forested areas; and
  - 0.050 for subcatchments with largely forested areas.
- Initial (IL) and continuing (CL) losses for the validation events were determined based on the model validation results as described in Section 4.4. The selection of initial and continuing losses for design events is described in Section 5.

4.3.3 Routing parameters

Channel routing in the XP-RAFTS model was configured based on specifying a 'K' and 'X' value for each routing link. A default 'X' value of 0.2 was adopted for all routing links. The 'K' values represent estimated flow travel times (in hours) and were initially calculated based on the flow path lengths and the following assumed flow velocities:

- 2.0 m/s for stream slopes of up to 1%;
- 3.0 m/s for stream slopes of between 1% and 3%; and
- 3.5 m/s for stream slopes of steeper than 3%.

These parameters were validated against the hydraulic model results in the vicinity of the Mine Site and the timing of the recorded hydrographs.

4.4 XP-RAFTS MODEL VALIDATION

4.4.1 Overview

The rating curves developed for the two water level recording stations were used to convert recorded water level hydrographs into discharge hydrographs for the three validation events. The resulting flow hydrographs were then used to validate the XP-RAFTS model. The initial loss and continuing loss rates for the three validation events were varied to achieve the best possible match to the recorded discharge hydrographs.

Table 4.2 shows the recorded peak flows in Hawkins Creek at the two stations for the three validation events. Table 4.2 also shows the preceding baseflow and the adopted initial and continuing losses for each event.

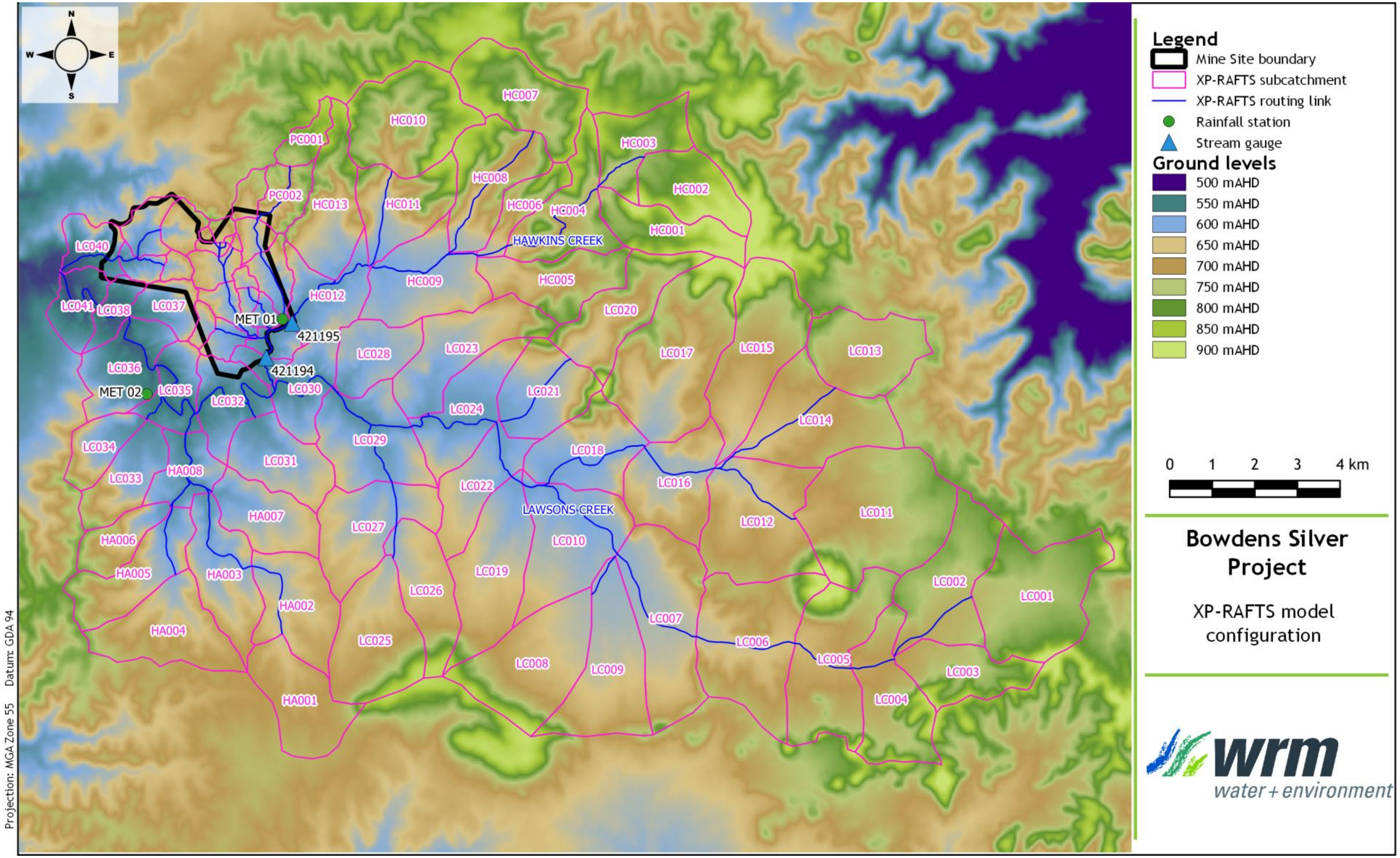


Figure 4.8 – XP-RAFTS model configuration

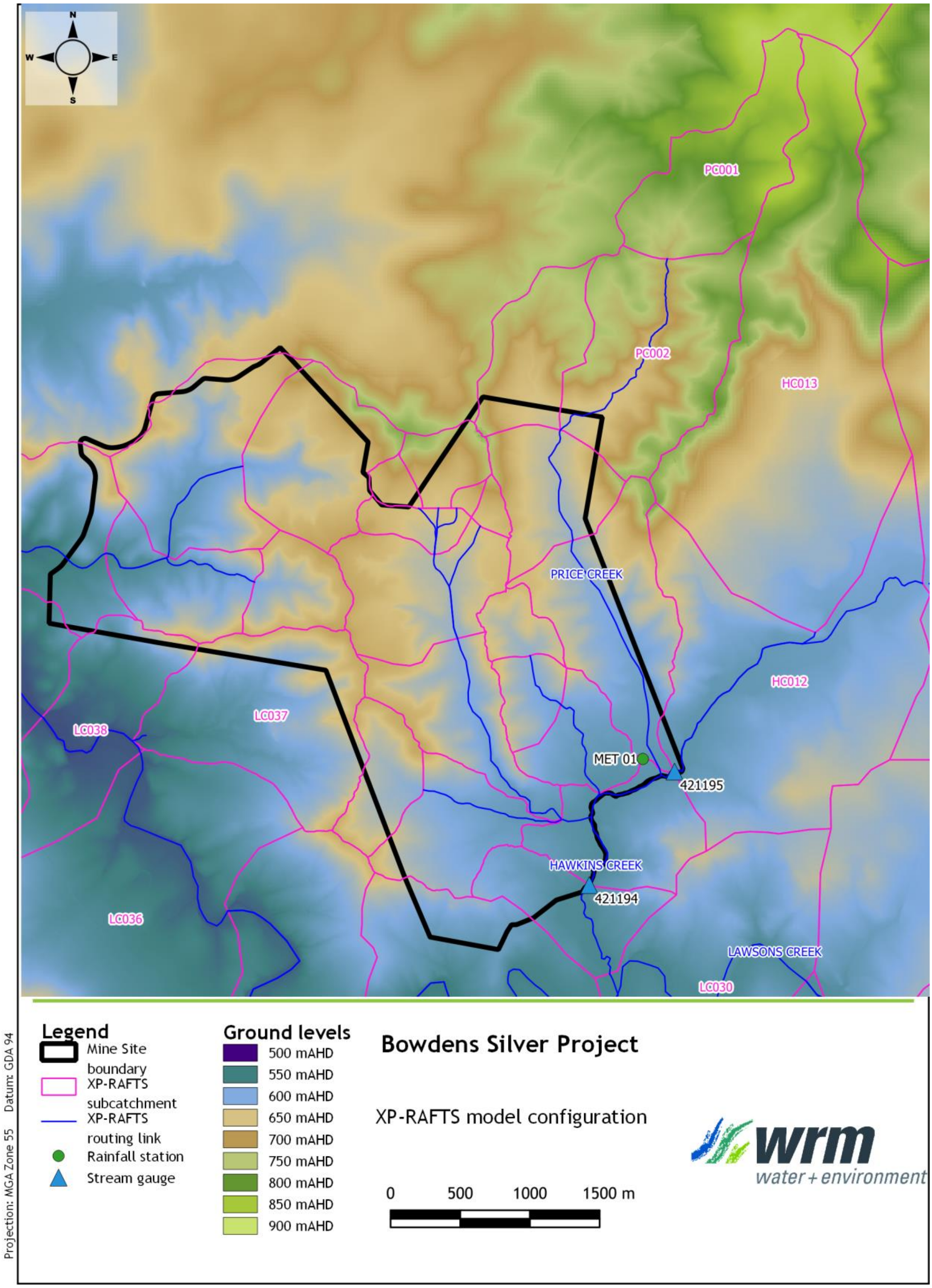


Figure 4.9 – XP-RAFTS model configuration within the Mine Site

Table 4.2 – Summary of recorded peak discharges at the water level recording stations operated by Bowdens Silver, with the XP-RAFTS adopted initial and continuing losses

Flow event	Event start date	Event finish date	Baseflow prior to event (m^3/s)	Peak discharge (m^3/s)		Adopted initial loss (mm)	Adopted continuing loss (mm/h)
				Bingmans Crossing (421194)	Powells Road (421195)		
July 2016	19/07/2016	21/07/2016	0.01	6.2	6.1	0.0	13.0
September 2016 (1st flow event)	31/08/2016	9/09/2016	0.00	7.6	7.4	38.0	4.0
September 2016 (2nd flow event)	18/09/2016	20/09/2016	0.19	14.2	24.8	0.0	11.0

4.4.2 Validation results

Comparisons between recorded and modelled peak discharge hydrographs for the three validation events are shown in the following figures:

- Figure 4.10 and Figure 4.11 for the July 2016 flow event at the Powells Road (421195) and Bingmans Crossing (421194) stations respectively;
- Figure 4.12 and Figure 4.13 for the September 2016 (1st flow event) at the Powells Road (421195) and Bingmans Crossing (421194) stations respectively; and
- Figure 4.14 and Figure 4.15 for the September 2016 (2nd flow event) at the Powells Road (421195) and Bingmans Crossing (421194) stations respectively.

The results show that very high continuing loss rates were required to achieve a good match to the peak discharges recorded during the July 2016 event and the September 2016 (2nd flow event). This is probably due at least in part, to the site rainfall recordings overestimating the catchment rainfall during the event. In contrast, the modelled peak discharge for the September 2016 (1st flow event) is within 15% to 20% of the recorded peak discharge with a continuing loss of 4.0 mm/h. The results show the model is able to reproduce the timing and shape of the hydrographs reasonably well.

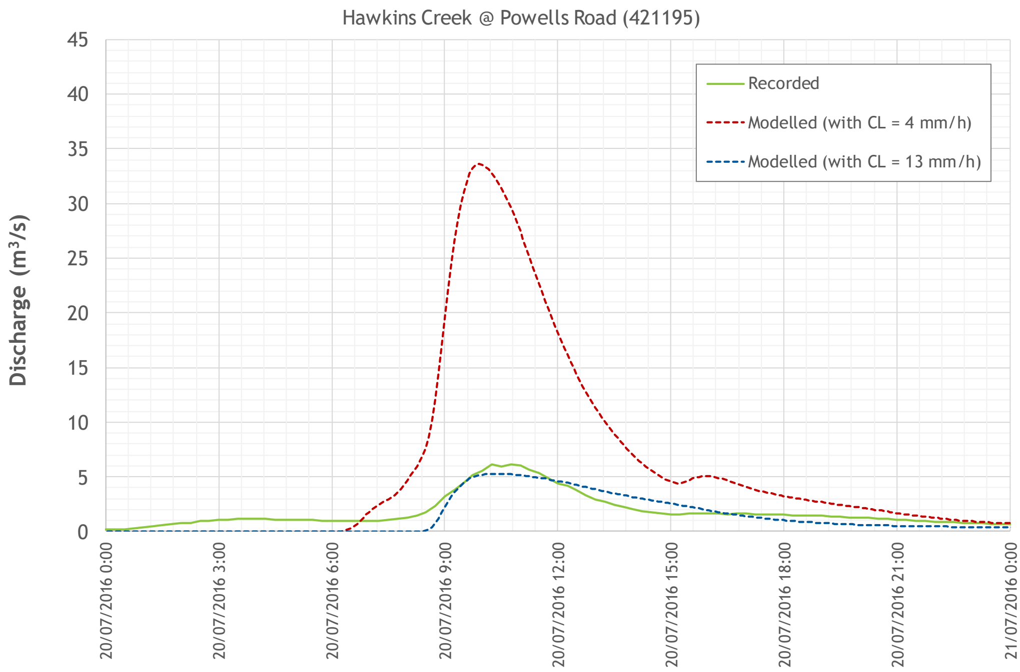


Figure 4.10 - Comparison of recorded and modelled discharge hydrographs for the July 2016 flow event - Hawkins Creek at Powells Road (421195)

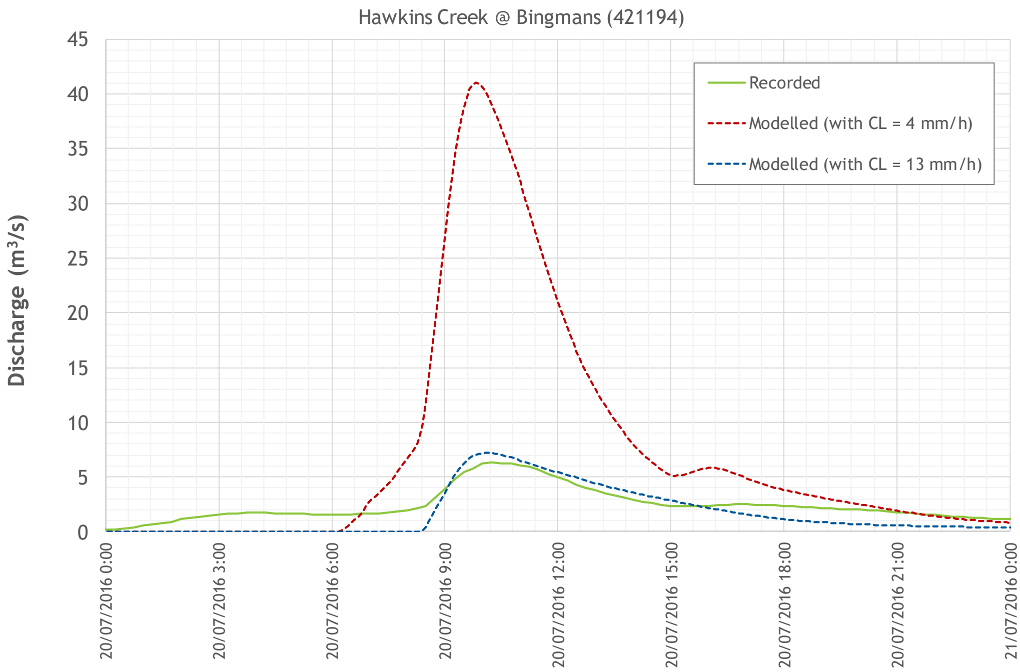


Figure 4.11 - Comparison of recorded and modelled discharge hydrographs for the July 2016 flow event - Hawkins Creek at Bingmans Crossing (421194)

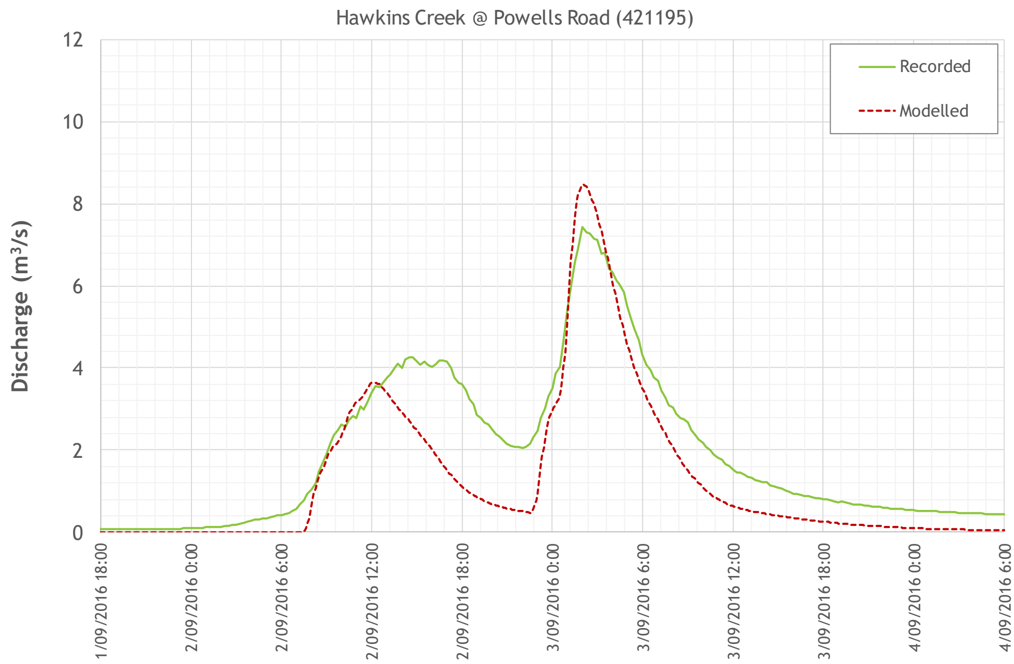


Figure 4.12 - Comparison of recorded and modelled discharge hydrographs for the September 2016 (1st flow event) - Hawkins Creek at Powells Road (421195)

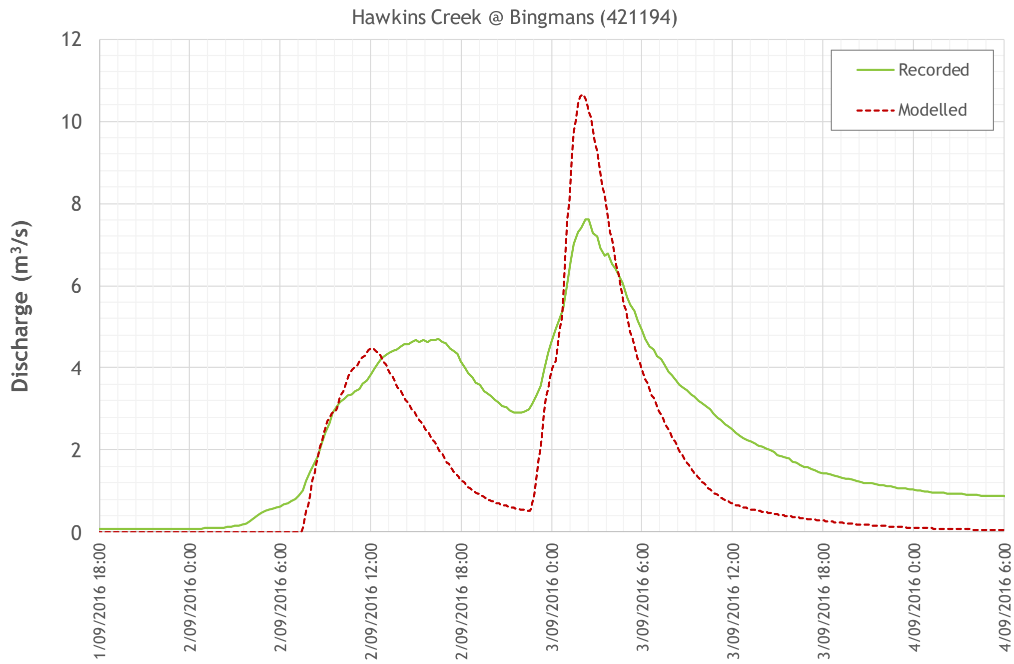


Figure 4.13 - Comparison of recorded and modelled discharge hydrographs for the September 2016 (1st flow event) - Hawkins Creek at Bingmans Crossing (421194)

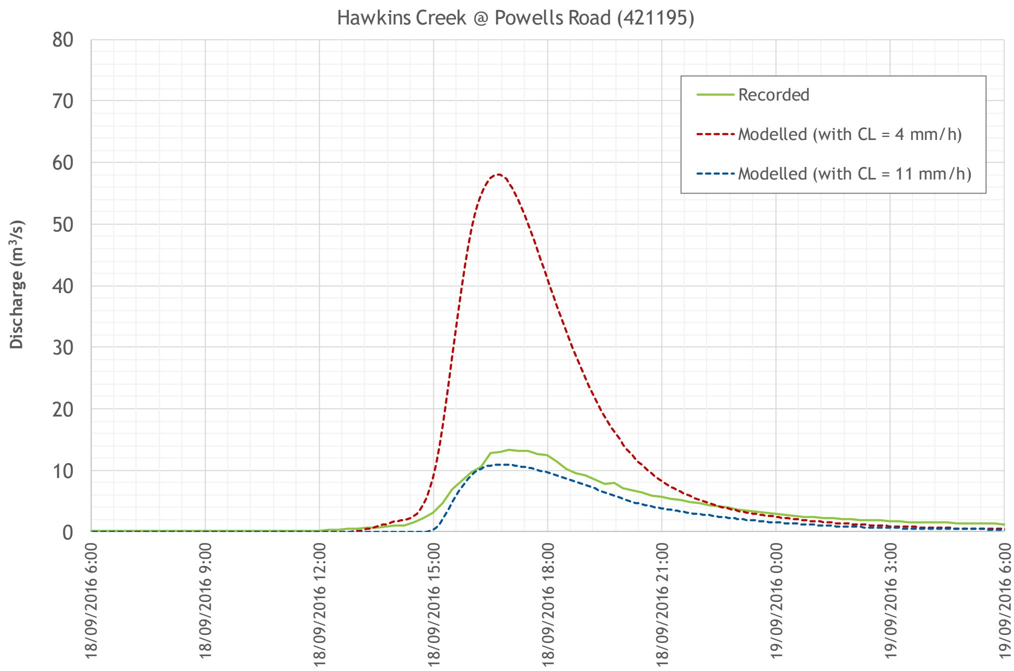


Figure 4.14 – Comparison of recorded and modelled discharge hydrographs for the September 2016 (2nd flow event) – Hawkins Creek at Powells Road (421195)

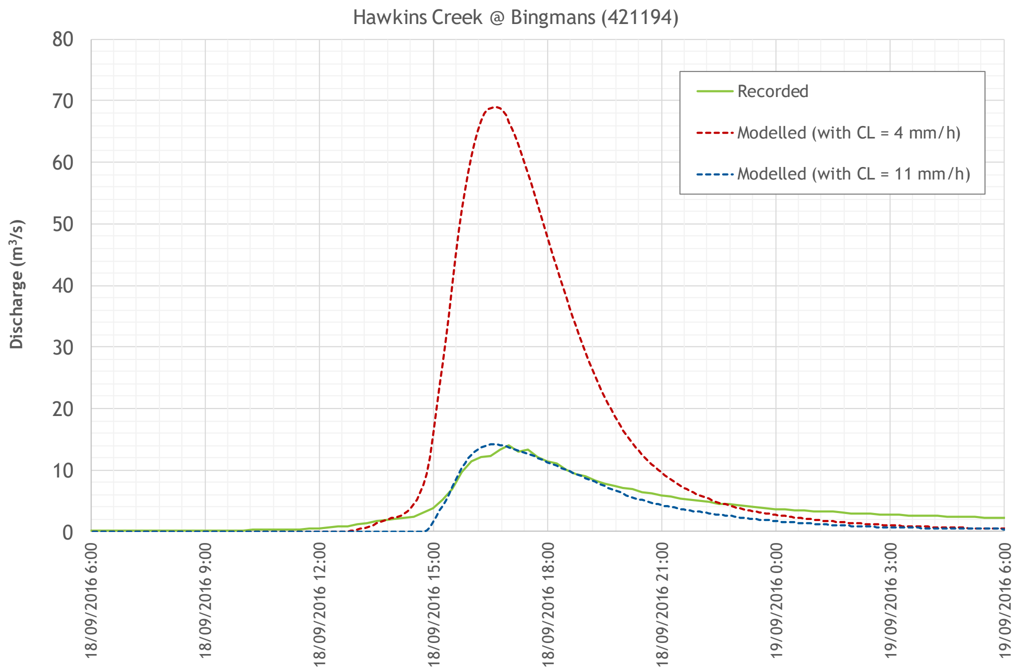


Figure 4.15 – Comparison of recorded and modelled discharge hydrographs for the September 2016 (2nd flow event) – Hawkins Creek at Bingmans Crossing (421194)

5 Estimation of design discharges

5.1 OVERVIEW

The XP-RAFTS model was used to derive flood discharge hydrographs for use in the hydraulic model. Design discharges were estimated based on the methodology described in the 2016 Australian Rainfall and Runoff (AR&R 2016) (Ball et al, 2019).

Design discharges were estimated for the 10% (1 in 10), 5% (1 in 20), 2% (1 in 50), 1% (1 in 100), 0.5% (1 in 200) and 0.2% (1 in 500) annual exceedance probability (AEP) events as well as the probable maximum precipitation (PMP) design event. Design flood discharge hydrographs were output for these seven design events and for a range of storm durations from 25 minutes up to 72 hours.

5.2 DESIGN RAINFALL DEPTH

5.2.1 10% to 0.2% AEP design events

Design rainfall depths and intensities were derived using intensity-frequency duration (IFD) data obtained from the Bureau of Meteorology's (BoM's) 2016 Rainfall IFD Data System. Design rainfall IFDs were obtained based on a point location at the centroid of the Lawsons Creek catchment to the XP-RAFTS model outlet.

For the 0.5% and 0.2% AEP design events, the BoM 2016 Rainfall IFD Data System does not provide design rainfall depth estimates for storm durations shorter than 24 hours. Therefore, rainfall depths for storm durations shorter than 24 hours for these events were derived by factoring the relevant 1% AEP design rainfall depths using 'growth curve factors' (Jordan et al, 2005) as recommended in Book 8 of AR&R 2016.

5.2.2 PMP design event

PMP rainfall depths for durations up to 6 hours were estimated using the methodology given in *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method (GSDM)* (BoM, 2003).

PMP rainfall depths for durations longer than 6 hours were estimated using the standard methodology given in *The Estimation of Probable Maximum Precipitation: Generalised Southeast Australia Method (GSAM)* (BoM, 2006) based on the catchment of Lawsons Creek upstream of the XP-RAFTS model outlet.

5.3 AREAL REDUCTION FACTORS

For design discharge estimation in Hawkins Creek and its minor tributaries that cross the Mine Site, an aerial Reduction Factor (ARF) of 1.0 was adopted for all design events up to the 0.2% AEP. This would provide a conservative design discharge estimates in the minor tributaries across the Mine Site.

For design discharge estimation in Lawsons Creek (which has a much larger catchment compared to Hawkins Creek and its tributaries), ARFs derived using the methodology in Book 2 of AR&R 2016 were adopted for design events up to and including 0.2% AEP.

For the PMP design event, the BoM (2003) and BoM (2006) guidelines were used.

5.4 TEMPORAL PATTERNS

5.4.1 10% to 1% AEP design events

Temporal patterns were obtained from the AR&R 2016 data hub based on a point location at the centroid of the Lawsons Creek catchment to XP-RAFTS model outlet. The AR&R 2016 temporal pattern methodology involves the use of an 'ensemble' of 10 temporal patterns, which produces 10 design storms for each duration for each AEP. The temporal pattern which results in a peak flood discharge closest to the average of the 10 design storms for each storm duration is selected as the representative temporal pattern for that storm duration.

As the critical storm duration would vary significantly across the catchment, the ensemble method were used to determine the representative temporal pattern that gives a peak flood discharge closest to the average at each key locations for each critical duration. This representative temporal pattern for each storm duration was adopted for hydraulic modelling.

5.4.2 0.5% AEP to PMP design events

The temporal patterns for storm durations up to and including 12 hours were obtained from the GSDM methodology (BoM, 2003). Temporal patterns for durations longer than 12 hours were obtained for Inland Zone storms from the GSAM methodology (BoM, 2006).

5.5 SPATIAL DISTRIBUTION

5.5.1 10% to 0.2% AEP design events

An assessment on rainfall IFDs (obtained from AR&R 2016) across the Lawsons Creek catchment indicate that design rainfall intensities across the catchment generally increase from east to west and from south to north. However, when compared to the rainfall intensities near the centroid of the Lawsons Creek catchment to the XP-RAFTS model outlet, the variation in rainfall intensities within the catchment was not significant. For this study, rainfall IFDs generated at the centroid of the Lawsons Creek catchment to the XP-RAFTS model outlet were adopted for the entire catchment.

5.5.2 PMP design event

Spatial distribution of rainfall for storm durations between 1 hour and 6 hours is accounted for in the GSDM (BoM, 2003) rainfall depth estimation methodology. Spatial distribution of rainfall for storm durations longer than 6 hours is accounted for in the GSAM (BoM, 2006) rainfall depth estimation methodology.

5.6 DESIGN RAINFALL LOSSES

5.6.1 Overview

For each design event up to and including 1% AEP, the design initial loss and continuing loss rates were selected so that the peak design discharge averaged from the ensemble of design temporal patterns was consistent with peak discharges estimated using the Regional Flood Frequency Estimation (RFFE) technique.

The RFFE is an automated web-based tool developed as part of AR&R 2016 guideline to estimate peak discharges for ungauged catchments based on data from nearby gauged catchments. It is recalled that recorded water level data for Hawkins Creek is available for this study. However, the period of record is too short and does not include any large flood events. Hence the recorded water level data is not suitable for validation of the XP-RAFTS model for large events. Therefore, the RFFE peak discharge estimates were used to validate the XP-RAFTS model estimates for flood events up to and including 1% AEP.

Taking a conservative approach, zero losses were adopted for extreme events larger than 1% AEP.

5.6.2 Adopted design losses

The AR&R 2016 data hub recommends the following design loss parameters (after modification by application of the "NSW continuing loss adjustment factor" of 0.4 recommended in the NSW Floodplain Risk Management Guide) for the area of interest:

- Initial loss = 23.0 mm; and
- Continuing loss = 1.3 mm/h (3.3 mm/h before modification).

Design loss rates were selected for modelling based on reconciliation with the FFA derived using the RFFE at key locations within the study area (as described in the following section). Table 5.1 shows the adopted initial loss and continuing loss rates for all modelled events. The adopted 1% AEP continuing loss rate of 1.5 mm/h is similar to the modified AR&R 2016 data hub value of 1.3 mm/h. The adopted continuing loss rates are well below the values inferred from the recorded streamflow data described in section 4.

Table 5.1 - Adopted design initial loss and continuing loss rates

Event	Initial loss (mm)	Continuing loss (mm/h)
10% AEP	25.0	3.0
5% AEP	15.0	3.0
2% AEP	5.0	2.0
1% AEP	1.0	1.5
0.5% AEP	0.0	0.0
0.2% AEP	0.0	0.0
PMP	0.0	0.0

5.6.3 Validation of design losses using RFFE peak discharge estimates

The RFFE was used to estimate design peak discharges up to and including 1% AEP at the following three locations:

- Hawkins Creek at Powells Road;
- Price Creek upstream of the Hawkins Creek confluence; and
- Lawsons Creek at the XP-RAFTS model outlet.

Figure 5.1, Figure 5.2 and Figure 5.3 compare XP-RAFTS predicted design peak discharges (using the adopted design losses) against RFFE estimates at the above three locations. The results show that XP-RAFTS predicted peak discharges generally match well with the RFFE estimates. On this basis, the XP-RAFTS model would produce reasonable estimates of design peak discharges using the adopted design rainfall losses. Design Price Creek discharges derived from the XP-RAFTS model are generally less than the RFFE values, and during later design phases consideration should be given to adopting further reduced loss rates for events with AEPs greater than 1%.

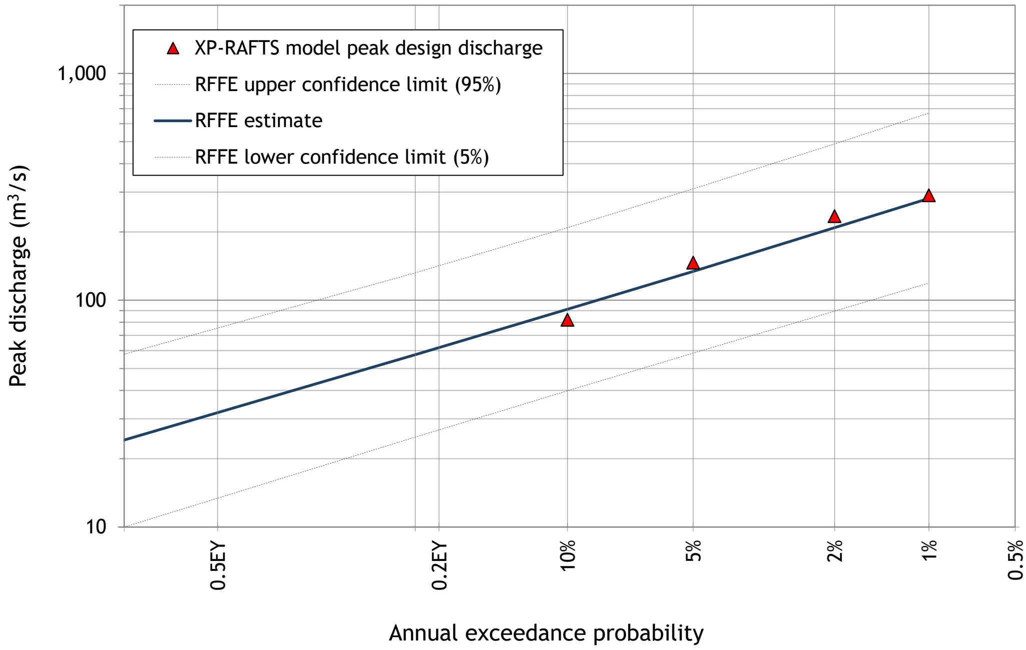


Figure 5.1 - Comparison of predicted XP-RAFTS design peak discharges against RFFE estimates, Hawkins Creek at Powells Road

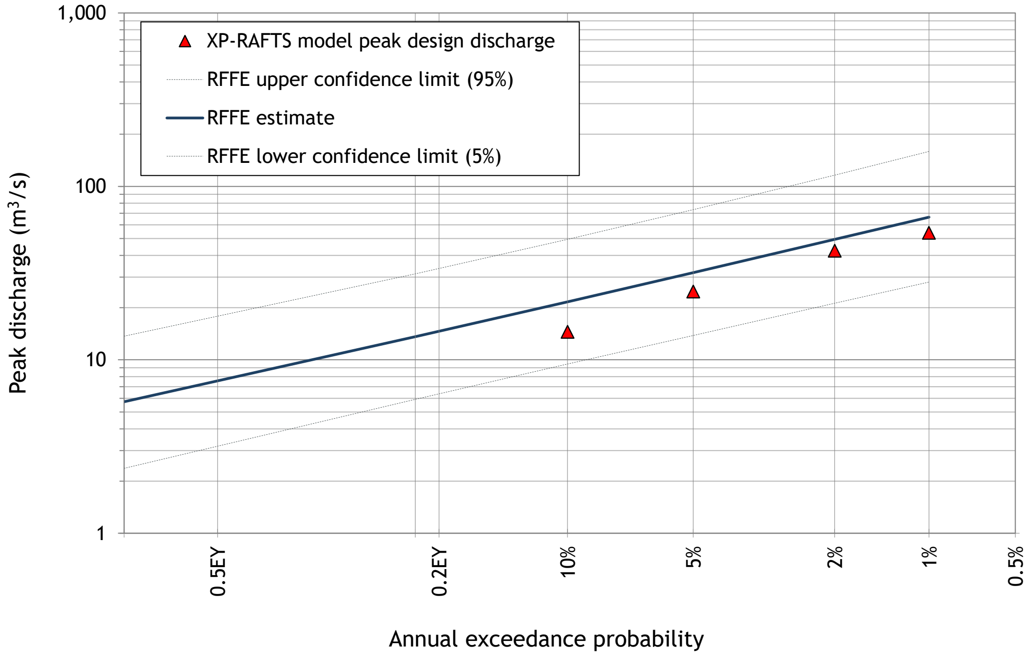


Figure 5.2 - Comparison of predicted XP-RAFTS design peak discharges against RFFE estimates, Price Creek upstream of Hawkins Creek confluence

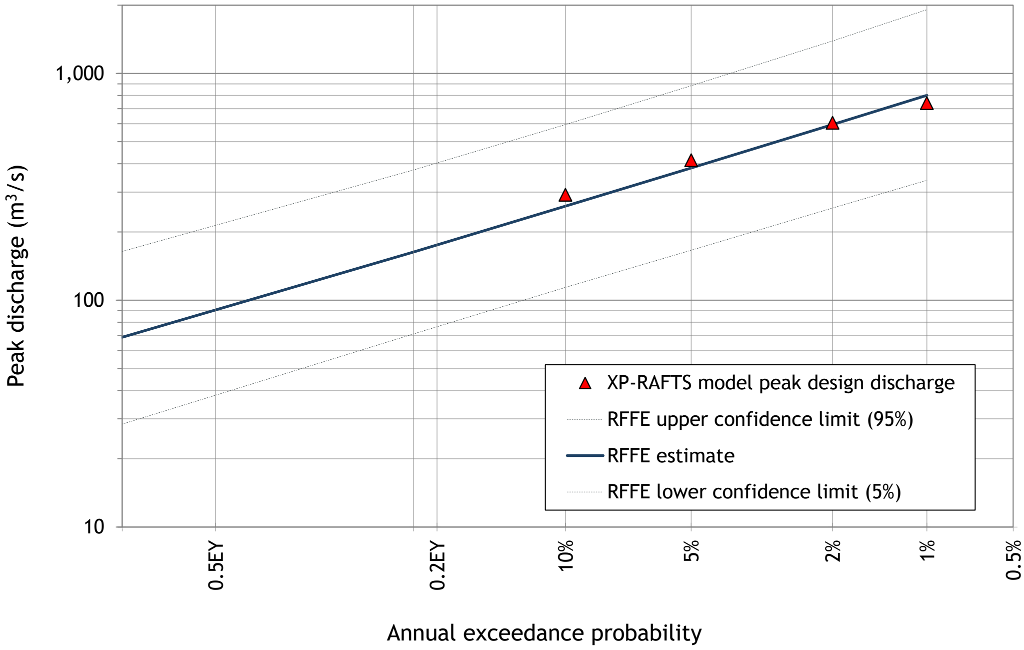


Figure 5.3 - Comparison of predicted XP-RAFTS design peak discharges against RFFE estimates, Lawsons Creek at XP-RAFTS model outlet

5.7 DESIGN DISCHARGES

Table 5.2 shows XP-RAFTS predicted design peak discharges and critical storm durations for all modelled design events at the following locations:

- Hawkins Creek at Powells Road;
- Price Creek upstream of the Hawkins Creek confluence; and
- Lawsons Creek at the XP-RAFTS model outlet.

The design peak discharges less than 0.5% were generated by one representative design storm which produced a peak discharge closest to the average of the 10 design storms for each storm duration at each location. For the PMP design storms, single temporal patterns were adopted for each duration in accordance with the GSDM methodologies.

To illustrate the range of peak discharges produced by the ensemble method of AR&R 2016, Appendix B provides box and whisker plots (box plots) to summarise the statistics of the XP-RAFTS model results for the 1% AEP design event at the above three locations. The box plots present the maximum, minimum, median, average, 25th and 75th percentile predicted peak discharges based on the model results for the 10 design storms for each storm duration. The XP-RAFTS model results indicate that the 10 design storms for each duration produced significantly different results. Notwithstanding this, design peak discharges were selected based on the average (mean) results from each ensemble (as suggested in AR&R 2016).

Table 5.2 – XP-RAFTS predicted design peak discharges and critical storm durations

AEP (%)	AEP (1 in X)	Peak discharge (m^3/s)			Critical storm duration (hours)		
		Hawkins Creek at Powells Road	Price Creek u/s of Hawkins Creek confluence	Lawsons Creek at XP-RAFTS model outlet	Hawkins Creek at Powells Road	Price Creek u/s of Hawkins Creek confluence	Lawsons Creek at XP-RAFTS model outlet
10%	10	82	15	292	12	6	12
5%	20	146	25	414	6	2	6
2%	50	235	43	606	3	1	6
1%	100	290	54	740	2	1	6
0.5%	200	383	69	1,312	2	1	3
0.2%	500	466	84	1,571	2	1	3
PMP	PMP	2,384	337	8,070	2	1	3

6 Hydraulic modelling

6.1 OVERVIEW

The TUFLOW hydrodynamic model (BMT, 2019) was used to simulate existing conditions flood behaviour in Lawsons Creek, Hawkins Creek and their tributaries for a range of design events. TUFLOW represents hydraulic conditions on a fixed grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow. The model automatically identifies breakout points and flow directions within the study area. All hydraulic modelling was undertaken using the TUFLOW Build 2017-09-AB HPC solver.

Flow paths within Lawsons and Hawkins Creeks are well defined for low flows. However, out-of-bank flows would occur in larger flood events such those modelled in this study. In addition, the channels of the various tributaries that cross the Mine Site are poorly defined with little capacity. Flows in the tributaries within the Mine Site would likely be conveyed by the floodplains of these tributaries as overland flow.

Out-of-bank flow conditions and the interaction between Hawkins and Lawsons Creeks and their much smaller tributaries would be poorly represented using simplistic one-dimensional modelling techniques. The TUFLOW modelling package is suited to simulation of dynamic hydraulic behaviour of complex overland flow in rural areas and was considered the most appropriate tool to determine the flood characteristics of Lawsons and Hawkins Creeks and their tributaries.

The discharges estimated using the XP-RAFTS runoff-routing model were adopted as inflows to the TUFLOW hydraulic model.

6.2 EXISTING CONDITIONS TUFLOW MODEL CONFIGURATION

6.2.1 Spatial configuration

Figure 6.1 shows the TUFLOW model configuration. The model covers an area of 11.5 km^2 and extends about 1.2 km upstream of the Mine Site along Hawkins Creek, and downstream to the XP-RAFTS model outlet (downstream of the confluence between Lawsons Creek and the TSF tributary.

The TUFLOW model was configured using a grid cell size of three metres. This provides a reasonable compromise between a coarse grid cell size sufficient for Lawsons and Hawkins Creeks, and a fine grid cell size required for the tributaries crossing the Mine Site.

6.2.2 Topography

Topographic LiDAR survey data for the area covered by the model was provided by Bowdens Silver in July 2017. The LiDAR data was converted into a digital terrain model (DTM) for use as the base TUFLOW model topography as well as mapping purposes.

6.2.3 Hydraulic roughness

Hydraulic roughness in the TUFLOW model is represented by Manning's 'n' roughness coefficients. Manning's 'n' values for the various land use types were selected based on typical published values (such as those in Chow (1959)). Land use types within the model were identified using aerial photography supplied by Bowdens Silver in August 2017.

The TUFLOW model was not calibrated to the recorded water level data at the Bowdens Silver recording stations (at Powells Road and Bingmans Crossing). Peak flows in Hawkins Creek recorded at these stations are too low (less than 20 m^3/s) and considered unsuitable for model calibration.

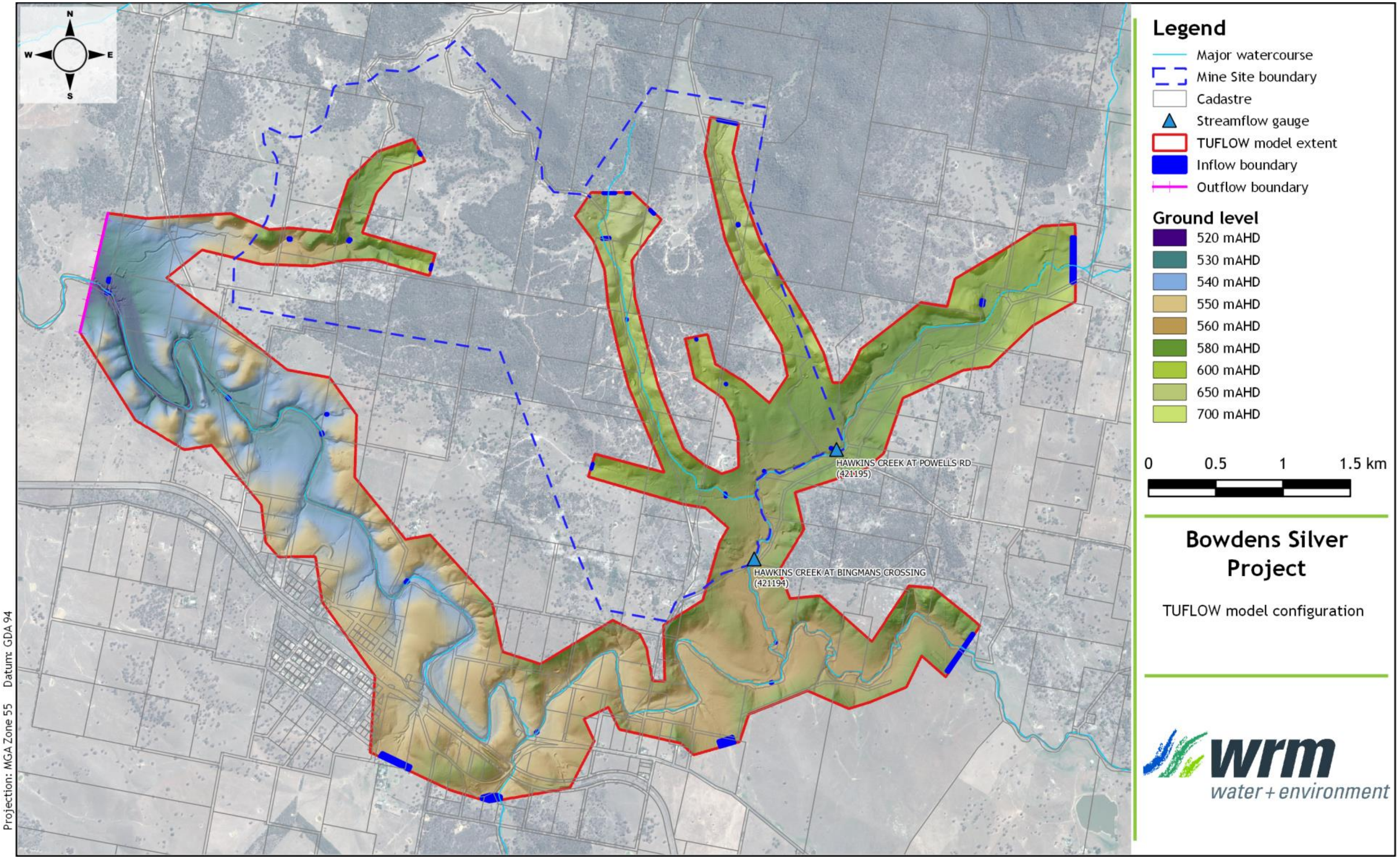


Figure 6.1 – TUFLOW model configuration

The adopted Manning's 'n' values in the TUFLOW model are as follows:

- River and creek channels - 'n' = 0.035;
- Floodplain (grassed open areas) - 'n' = 0.035;
- Moderate vegetation – 'n' = 0.05
- Dense vegetation - 'n' = 0.07; and
- Road - 'n' = 0.025.

6.2.4 Model inflow and outflow boundaries

Figure 6.1 shows the locations of inflow and outflow boundaries in the TUFLOW model. The model includes a total of 36 inflow boundaries. The model inflow boundaries were applied within the 2D model domain using surface-area "SA" polygons. Using this approach, flows are initially applied to the lowest point within each SA polygon. Design discharge hydrographs for these inflow boundaries were obtained from the XP-RAFTS hydrologic model.

As discussed in Section 5.4, the critical storm duration would vary significantly across the catchment. Therefore, the TUFLOW model was run using discharge hydrographs for various storm durations to ensure that the peak flood level is represented at all locations within the model. The TUFLOW model was run for one representative design storm for each storm duration.

A single rating curve outflow boundary was adopted based on a flood slope of 0.1%, which is the approximate bed slope at this location.

6.2.5 Hydraulic structures

Lawsons Creek is crossed by roads at the following locations within the model domain:

1. Bara-Lue Road;
2. Private access to property on Gunther Street, Lue;
3. Private access to property on Peel Street, Lue;
4. Pyangle Road – which comprises 5 reinforced box culverts, with the road crest at bank level and the approaches in cut.

As crossings 1 to 3 are low level crossings at the bed of the stream, they would have no perceptible impact on flood conditions. The Pyangle Road crossing would be drowned once flood levels significantly exceeded the road crest level. As the model results show that even during extreme events, inundation due to Lawsons Creek flooding would not extend within 250 m of the Mine Site the effect of these structures on flood levels has not been assessed in the hydraulic model.

6.3 EXISTING CONDITIONS FLOODING

6.3.1 Overview

Flood maps showing design peak flood levels, depths and velocities under existing conditions for the 1% (1 in 100) AEP event are shown in the following figures:

- Figure 6.2 and Figure 6.6 – for the entire hydraulic model extent;
- Figure 6.3 and Figure 6.7 – for the eastern extent (the locations of the proposed mining pit, processing plant and waste rock emplacements);
- Figure 6.4 and Figure 6.8 – for the western extent (the location of the proposed TSF); and
- Figure 6.5 and Figure 6.9 - for the Lawsons Creek extent (the location of the proposed mine access road).

Flood maps showing design peak flood levels, depths and velocities under existing conditions for the 10% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMP design events at the above locations are provided in Appendix C.

6.3.2 Peak flood levels and depths

Key points with regards to predicted peak flood levels and depths across the study area are summarised below:

- The Project disturbance area is located outside of the Lawsons Creek flood extent or all events up to the PMP design event.
- The area along the southeastern Mine Site boundary is affected by flooding from Hawkins Creek. However, the proposed open cut pits, WRE and leachate management dam are located outside of the predicted flood extent for Hawkins Creek for all events up to the PMP design event.
- Flooding along the Hawkins and Lawsons Creeks tributaries within the Mine Site is characterised by shallow overland flows. Flows in these tributaries are generally confined within the narrow floodplains, with no breakouts occurring except near the confluences of these tributaries with Hawkins and Lawsons Creeks. Due to the narrow floodplains, the difference in predicted flood extents along these tributaries between the 1% AEP and PMP design events are not significant.
- Predicted peak flood depths along the overbank areas of the Hawkins and Lawsons Creeks tributaries are generally below one metre for events up to and including 0.2% AEP. Peak flood depths of up to 1.5 m for the PMP design event are predicted in some sections along these tributaries.

6.3.3 Peak flood velocities

Key points with regards to predicted peak velocities across the study area are summarised below:

- Flows in the Lawsons and Hawkins Creeks tributaries are generally confined within narrow floodplains with relatively steep ground slopes. This results in relatively high predicted peak flood velocities of up to 2.5 m/s along the channel and overbank areas of these tributaries for events up to and including 0.2% AEP. For the PMP design event, peak flood velocities greater than 4 m/s are predicted in many sections along these tributaries.
- Predicted peak flood velocities in Hawkins Creek for events up to and including 0.2% AEP are generally less than 3 m/s, with peak velocities greater than 4 m/s predicted in some sections. For the PMP design event, peak flood velocities greater than 4 m/s are predicted throughout the Hawkins Creek main channel and in large areas of the floodplain.
- Predicted peak flood velocities in Lawsons Creek are relatively high for all modelled events. For events up to and including 0.2% AEP, peak flood velocities greater than 4 m/s are predicted in many sections along the Lawsons Creek channel and floodplain. For the PMP design event, peak velocities greater than 4 m/s are predicted throughout and Lawsons Creek main channel and large areas of the floodplain.

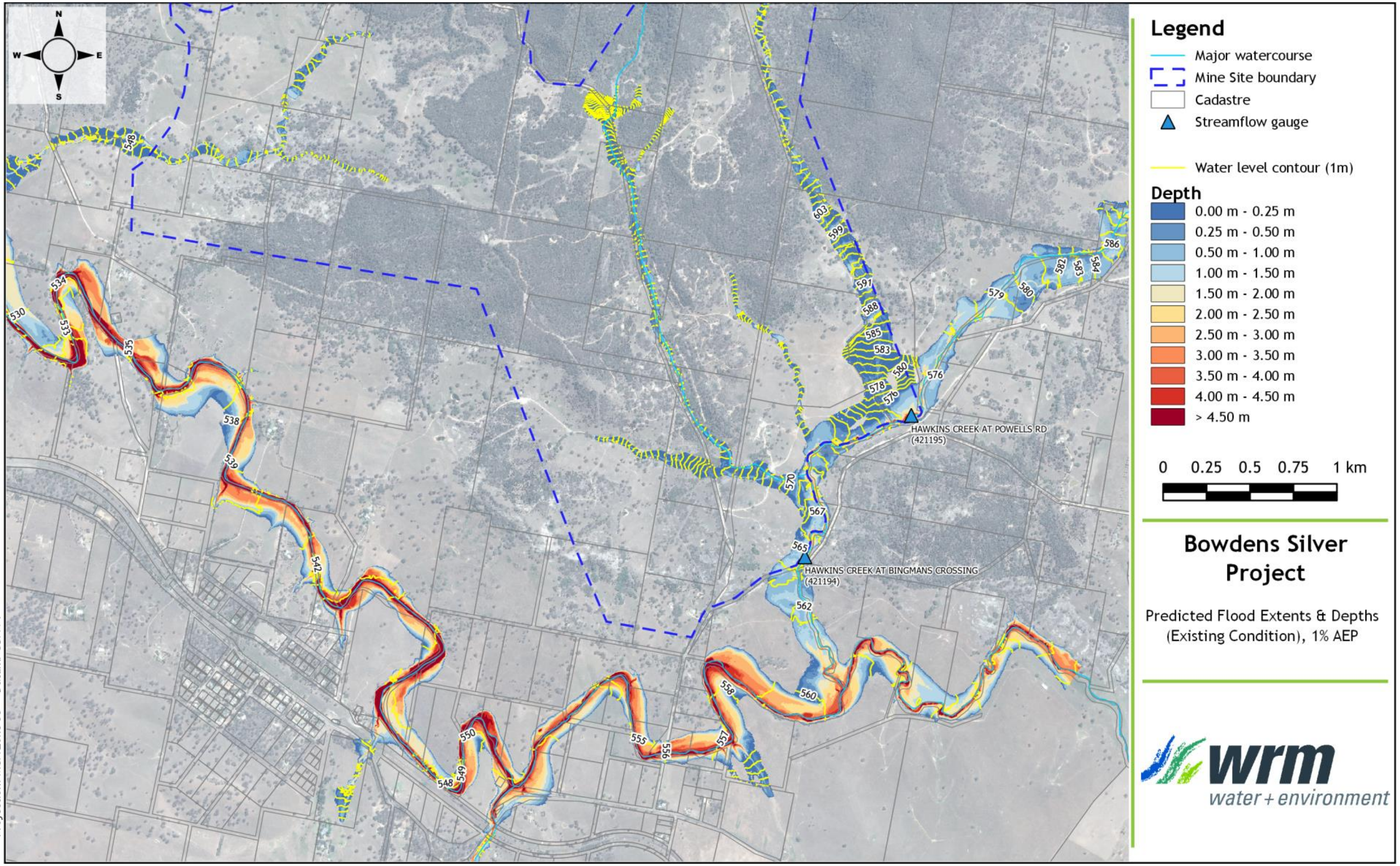


Figure 6.2 – 1% (1 in 100) AEP peak flood levels and depths – existing conditions – complete extent

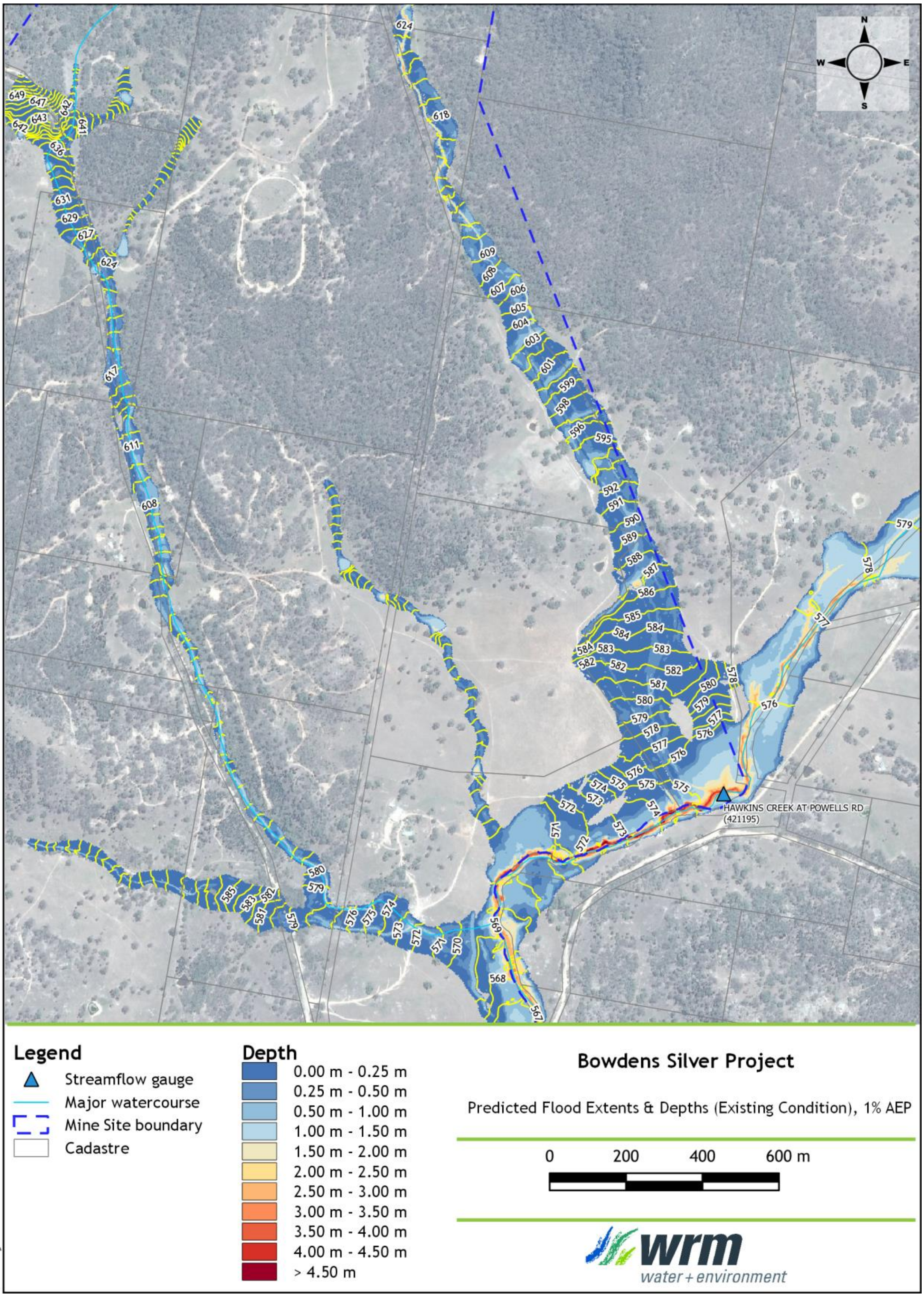


Figure 6.3 – 1% (1 in 100) AEP peak flood levels and depths – existing conditions - eastern extent

Figure 6.4 – 1% (1 in 100) AEP peak flood levels and depths – existing conditions – western extent

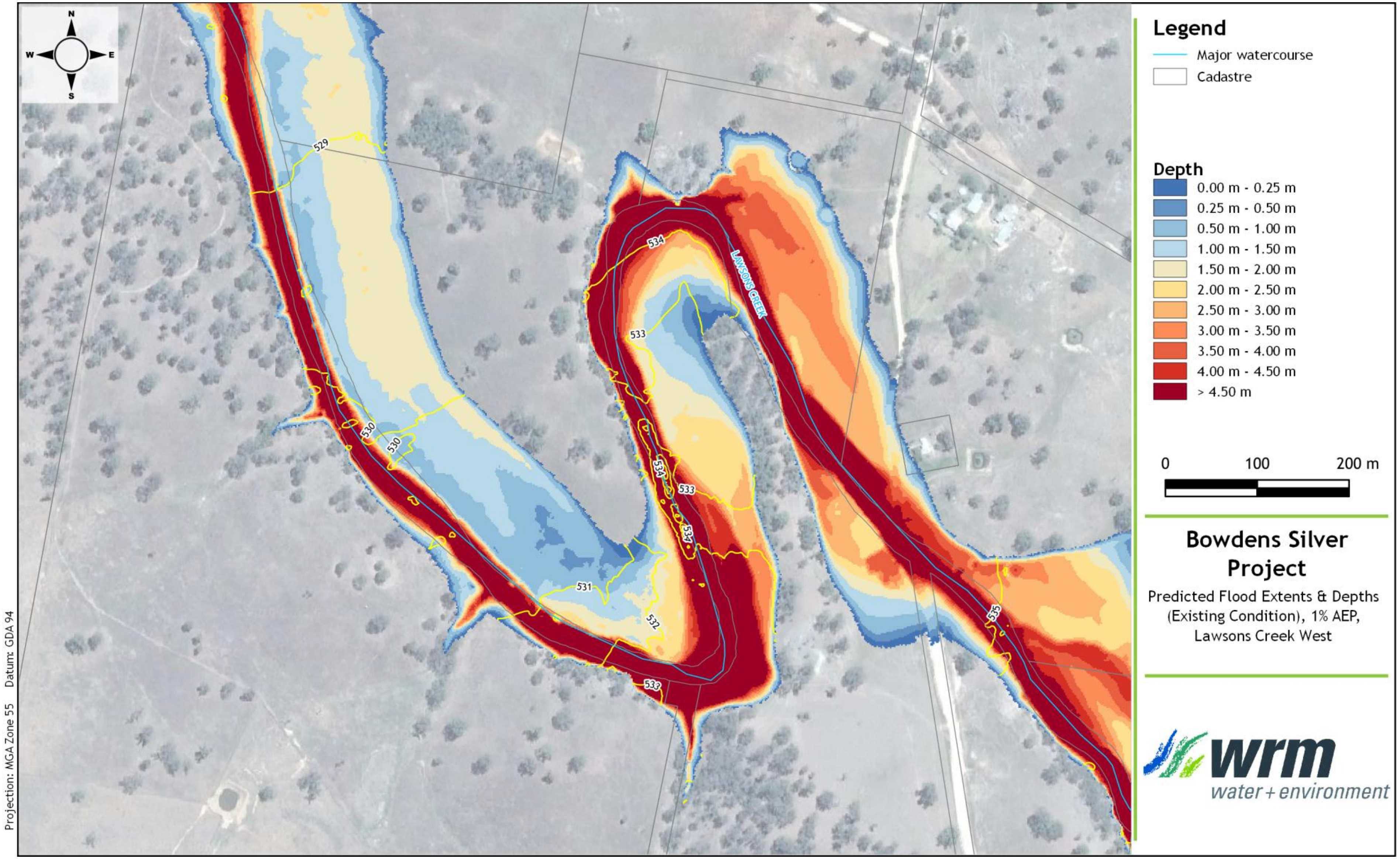


Figure 6.5 – 1% (1 in 100) AEP peak flood levels and depths – existing conditions – Lawsons Creek extent

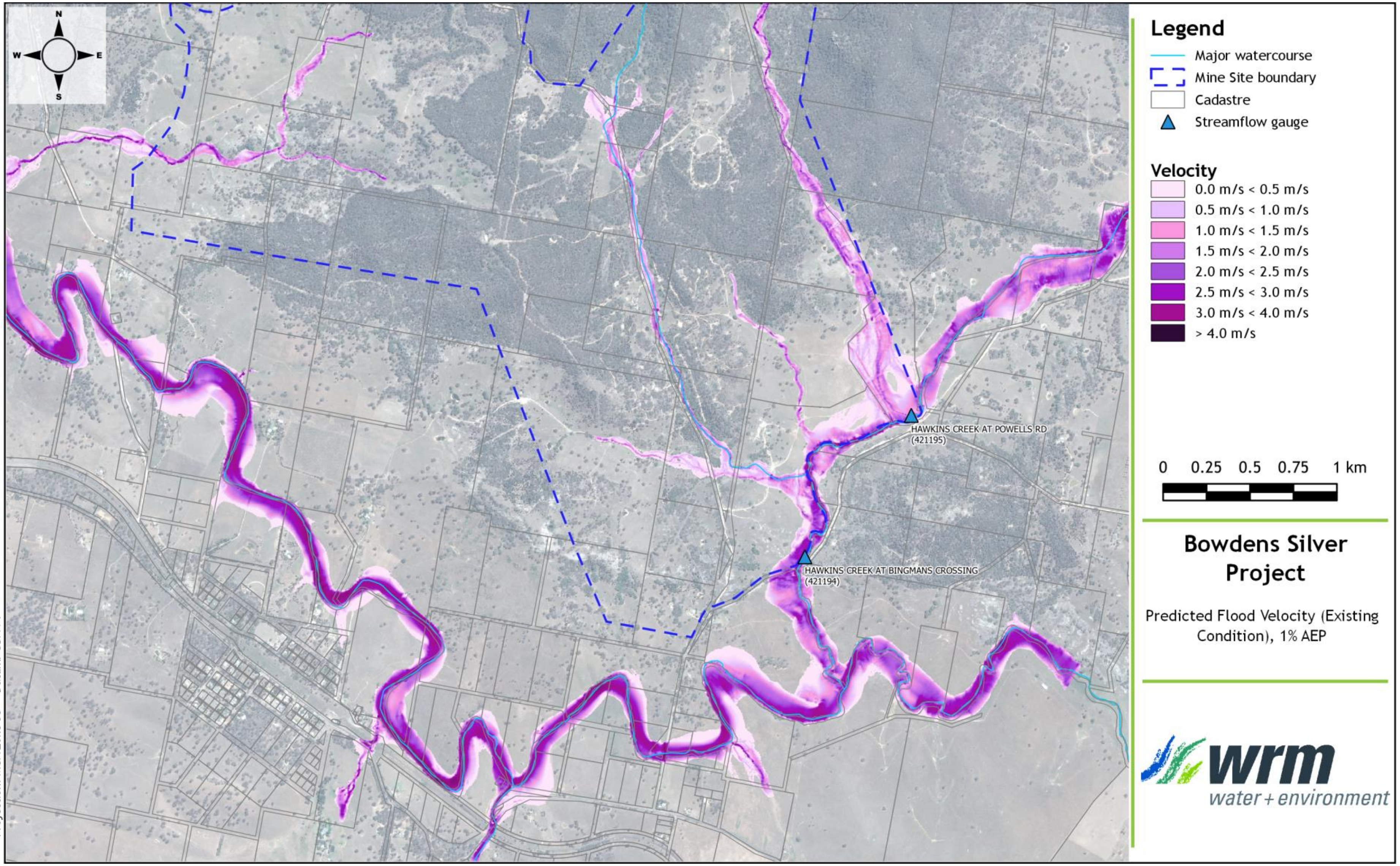


Figure 6.6 – 1% (1 in 100) AEP peak flood velocities – existing conditions – complete extent

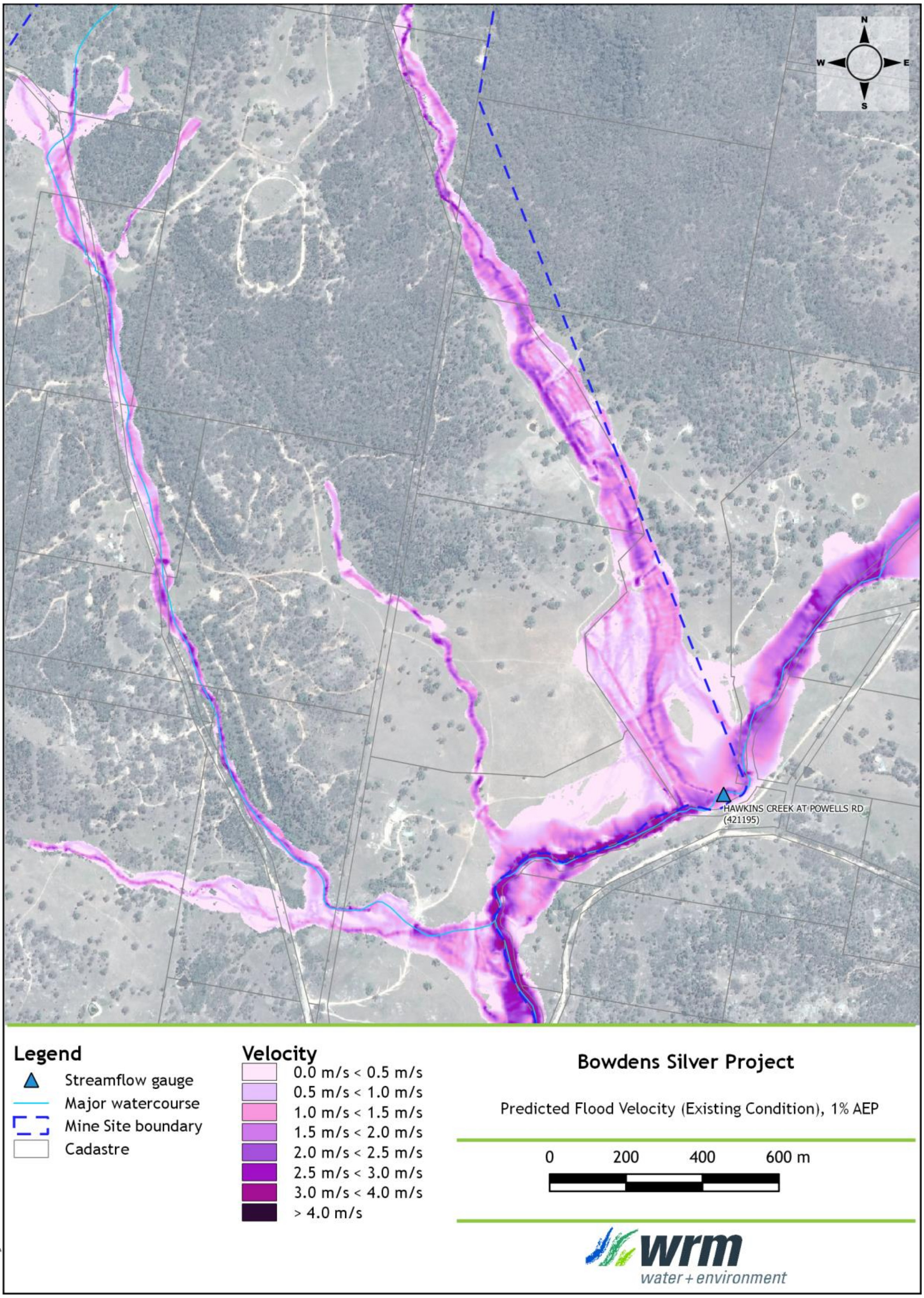


Figure 6.7 – 1% (1 in 100) AEP peak flood velocities – existing conditions – eastern extent

Figure 6.8 – 1% (1 in 100) AEP peak flood velocities – existing conditions - western extent

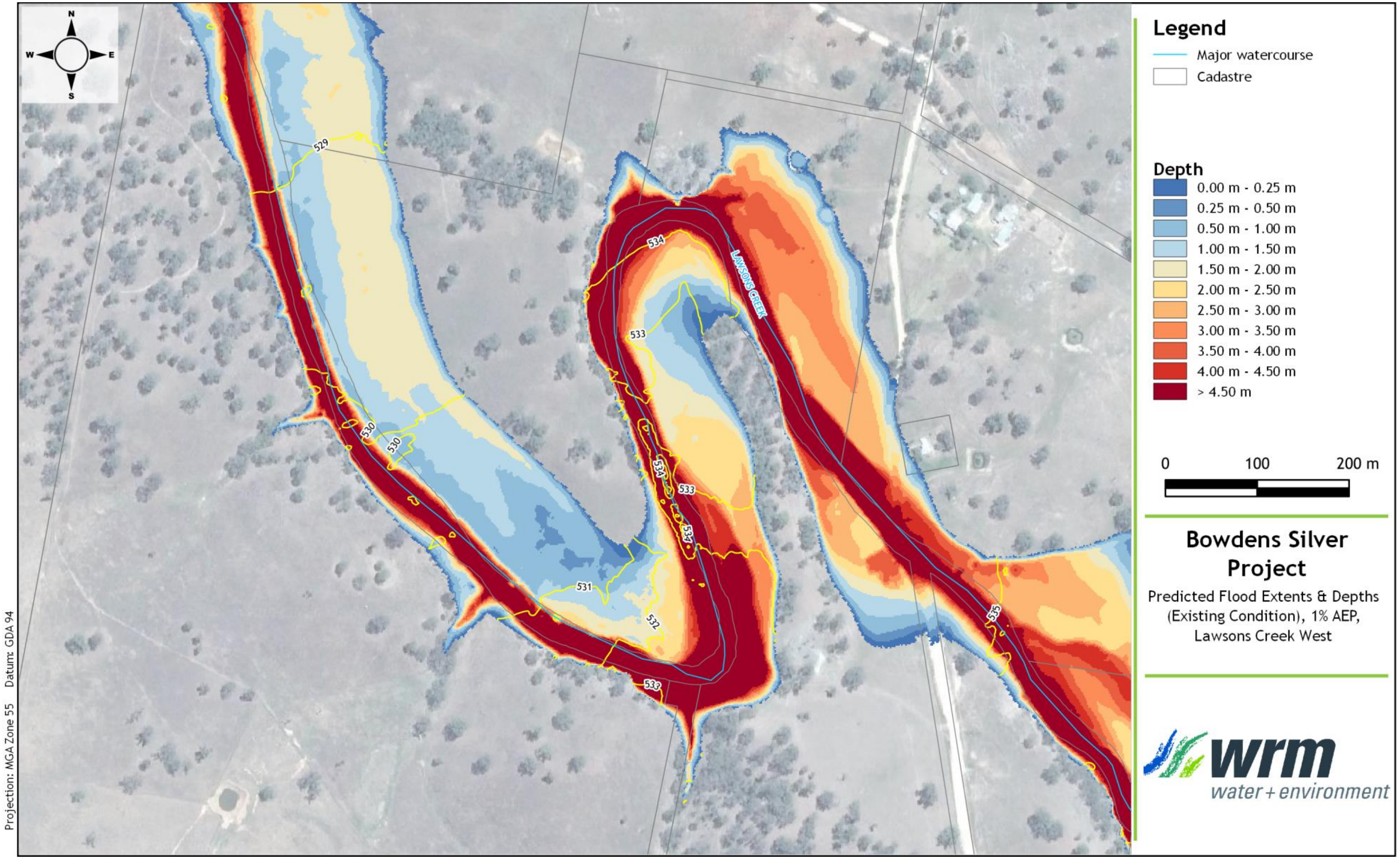


Figure 6.9 – 1% (1 in 100) AEP peak flood velocities – existing conditions – Lawsons Creek extent

6.4 DEVELOPED CONDITIONS TUFLOW MODEL CONFIGURATION

6.4.1 Overview

The existing conditions TUFLOW model was modified to include the proposed infrastructure, including the proposed WRE and associated haul roads and leachate management dam, southern barrier, oxide ore stockpile and Lawsons Creek crossing (relocated Maloneys Road (Pyangle Road)).

The developed conditions TUFLOW model was run for the following three scenarios:

- **'Maximum disturbance'** – this scenario represents Year 16 of mining where the extent of mine disturbance is greatest.
- **'Final landform'** – this scenario represents post-mining conditions.
- **'Lawsons Creek crossing'** – this scenario incorporates the proposed Lawsons Creek crossing and associated culverts.

6.4.2 TUFLOW model modifications

6.4.2.1 Maximum disturbance and final landform scenarios

Figure 6.10 shows the modifications made to the TUFLOW model in the vicinity of Price Creek for the 'Maximum Disturbance' scenario. Figure 6.11 shows the modifications made to the TUFLOW model in the vicinity of Price Creek for the 'Final Landform' scenario.

Design surface tins of the WRE were provided by RW Corkery & Co for various stages of mining. The WRE adjacent to Price Creek was incorporated directly into the TUFLOW model topography.

It is also proposed to divert flows from the upper catchment of Blackmans Gully around the mine infrastructure area (via a drainage channel) and into Price Creek. To represent this, the base case TUFLOW inflow boundaries located in the upper catchment of Blackman Gully were relocated to the approximate location of the drainage channel's outlet, which is just to the northeast of the WRE (as shown in Figure 6.10 and Figure 6.11).

For these two scenarios, water would be lost to the open cut pits, the WRE, the mine infrastructure area and the upstream diversion of the Blackmans Gully catchment. To account for this, TUFLOW inflows in Blackmans Gully were reduced in proportion to the reduction in catchment in the developed conditions.

The TUFLOW outflow boundary as well as the adopted hydraulic roughness distribution were unchanged from the existing conditions model.

6.4.2.2 Lawsons Creek crossing scenario

Figure 6.12 shows the modifications made to the TUFLOW model in the vicinity of the Lawsons Creek crossing for the 'Lawsons Creek Crossing' scenario.

The proposed crossing would be designed to be overtopped by flows in Lawsons Creek during a 10% AEP event. TUFLOW z-shapes were used to represent the proposed crossing embankment. The proposed culverts (10 barrels of 2.7 m (L) x 2.4 m RCBCs) were modelled as a 1d network linked to the 2D model domain.

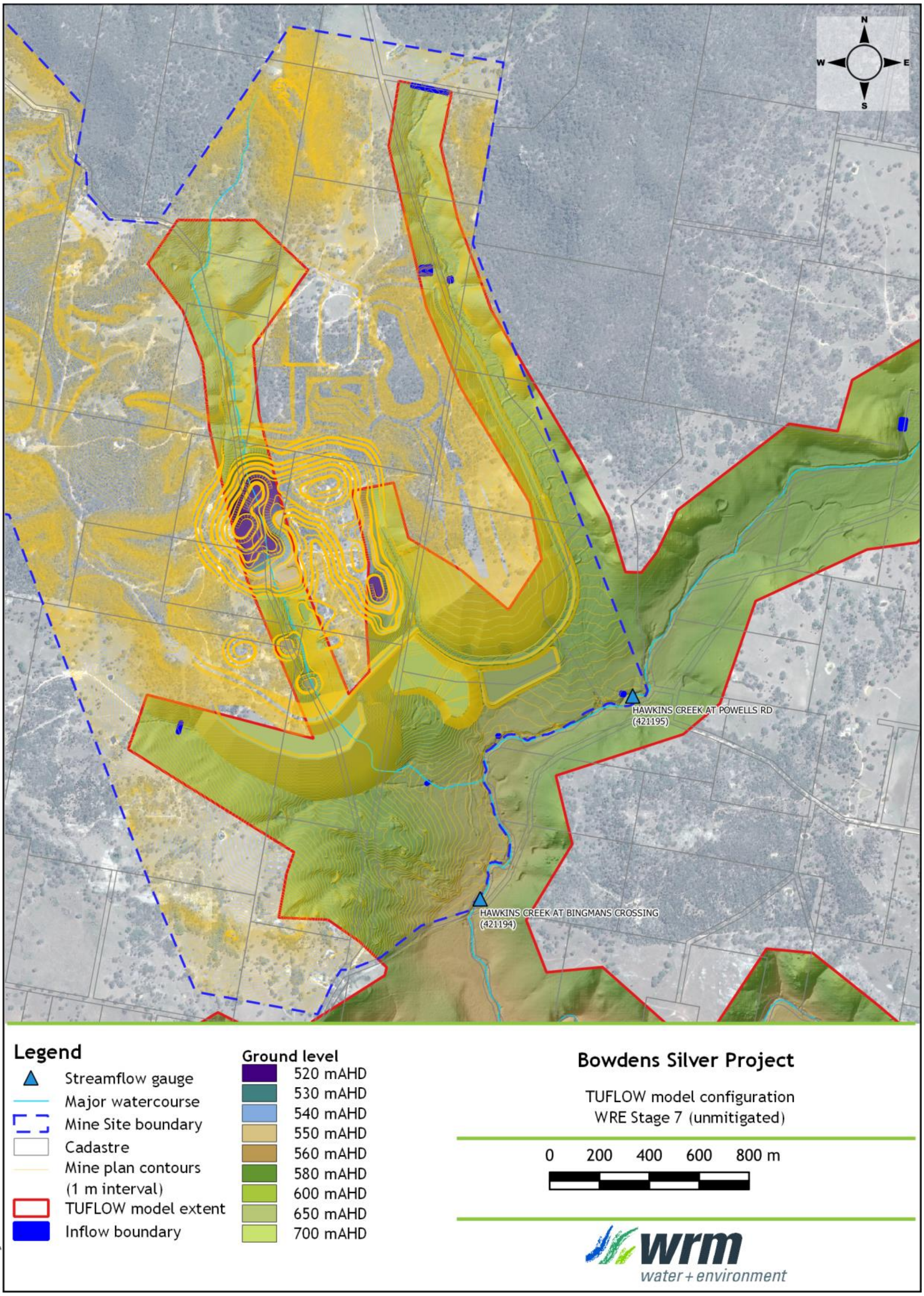


Figure 6.10 – Developed conditions TUFLOW model, 'Maximum Disturbance' scenario

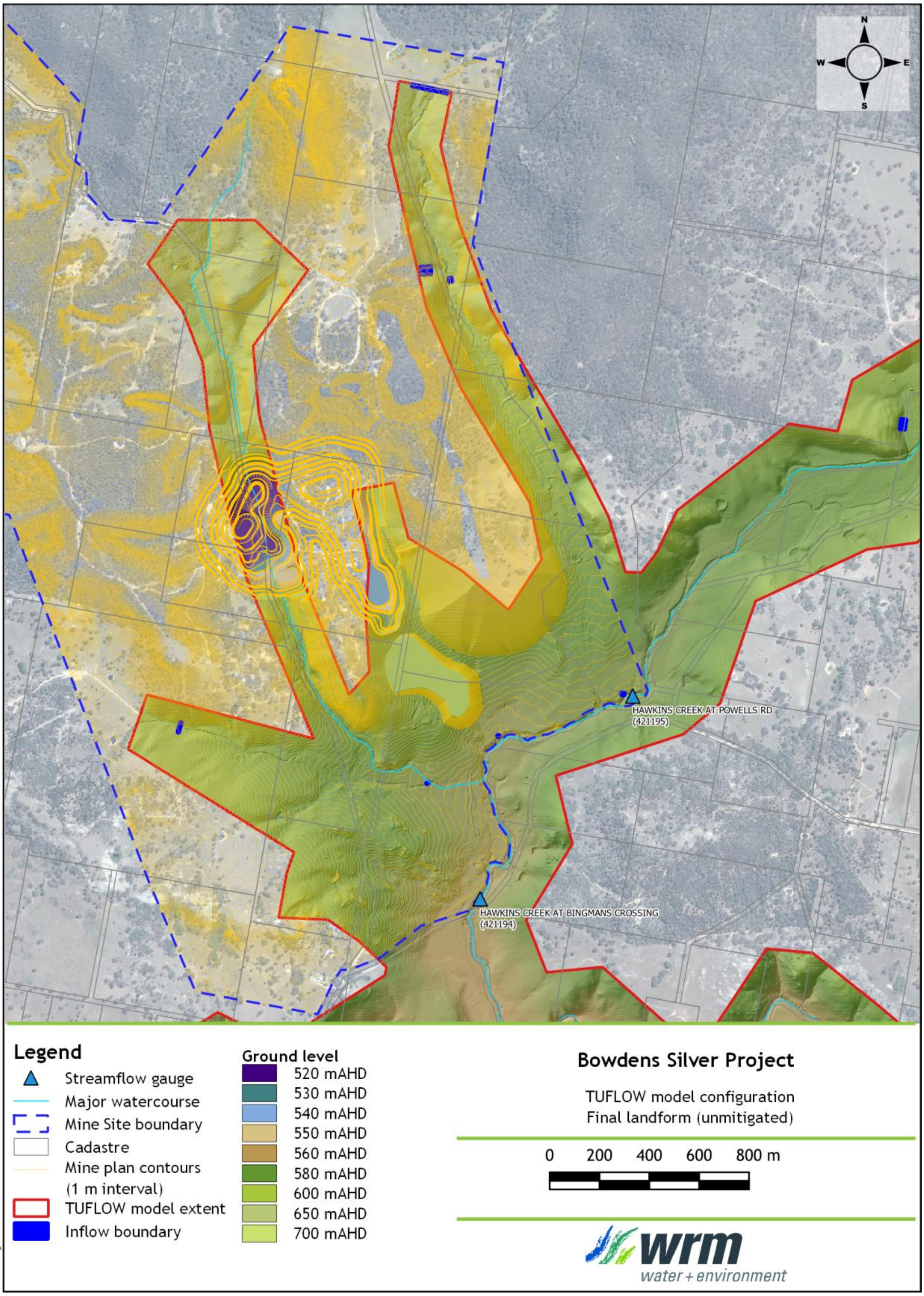


Figure 6.11 – Developed conditions TUFLOW model, 'Final Landform' scenario

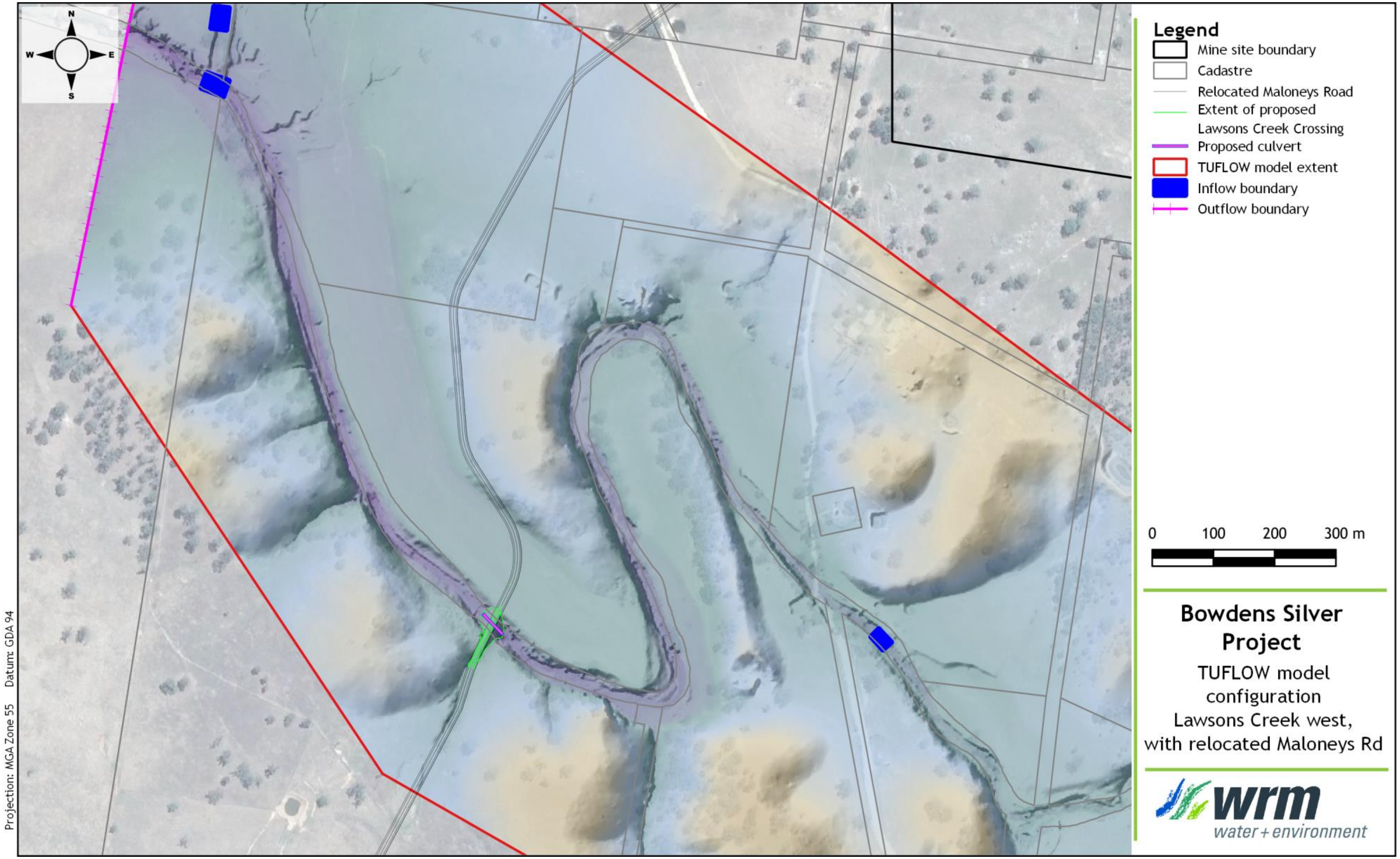


Figure 6.12 – Developed conditions TUFLOW model, 'Lawsons Creek Crossing' scenario'

7 Hydraulic impact assessment

7.1 OVERVIEW

The developed conditions TUFLOW model was used to estimate design peak flood levels, depths, extents and velocities for the 'Maximum Disturbance', 'Final Landform' and 'Lawsons Creek Crossing' scenarios for the 10% AEP, 1% AEP, 0.2% AEP and PMF events.

7.2 DEVELOPED CONDITIONS FLOODING

7.2.1 Maximum disturbance scenario

Figure 7.1 shows predicted peak flood levels and depths for the 1% (1 in 100) AEP event under the Maximum Disturbance Scenario in the vicinity of the proposed WRE. Figure 7.2 shows the corresponding 1% AEP peak velocities. Figure 7.3 shows (in greater detail) the predicted peak velocities along Price Creek adjacent to the proposed WRE for the Maximum Disturbance Scenario.

Flood maps showing design peak flood levels, depths and velocities under the Maximum Disturbance Scenario for the 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF design events are provided in Appendix D.

The model results for this scenario indicate the following:

- The running surface of the proposed haul road at the toe of the proposed WRE would have immunity from flooding for all events up to the PMF.
- The leachate management dam would be located outside the extent of flooding in the 0.2% AEP flood.
- The northeastern section of the proposed haul road embankment would constrict flows in Price Creek. As a result, high peak velocities are predicted here. The predicted maximum velocities just downstream of this constriction range from 3.2 m/s for 10% AEP event to 4.9 m/s for the 1% AEP event. Mitigation measures for managing the short-term risk of erosion in these areas would be developed during detailed design.
- Some sections of the proposed haul road and WRE encroach into the Price Creek floodplain. As a result, the toe of the haul road located within the Price Creek flood extent would potentially be affected by high velocities. The predicted maximum velocities along the eastern edge of the proposed haul road range from 3.2 m/s for the 10% AEP event to 3.5 m/s for the 1% AEP event.

7.2.2 Final landform scenario

Figure 7.4 shows predicted peak flood levels and depths for the 1% (1 in 100) AEP event under the Final Landform Scenario in the vicinity of the proposed WRE. Figure 7.5 shows the corresponding 1% AEP peak velocities. Figure 7.6 shows (in greater detail) the predicted peak velocities along Price Creek adjacent to the proposed WRE for the Final Landform Scenario.

Flood maps showing design peak flood levels, depths and velocities under the Final Landform Scenario for the 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF design events are provided in Appendix E.

The model results for this scenario indicate the following:

- The proposed haul road would be regraded from the toe of the WRE towards the existing ground level at the edge of the Price Creek floodplain as part of rehabilitation at mine closure. However, the predicted flood extent, depths and velocities along Price Creek are very similar to those predicted for the Maximum Disturbance Scenario.

- The constriction at the northeastern corner of the WRE would still exist in the Final Landform. As a result, high peak velocities are also predicted here. The predicted maximum velocities just downstream of this constriction range from 3.2 m/s for 10% AEP event to 4.9 m/s for the 1% AEP event. Long-term measures for mitigating the consequent risk of erosion would be incorporated into the rehabilitation design.
- Some sections of the WRE would still encroach into the Price Creek floodplain. As a result, the toe of the WRE located within the Price Creek flood extent would potentially be affected by high velocities. The predicted maximum velocities along the eastern edge of the proposed haul road range from 2.5 m/s for the 10% AEP event to 3.4 m/s for the 1% AEP event. Long-term measures for mitigating the consequent risk of erosion would be incorporated into the rehabilitation design.

7.2.3 Lawsons Creek crossing

Figure 7.7 and Figure 7.8 show predicted peak flood levels and depths for the 10% (1 in 10) and 1% (1 in 100) AEP events respectively in Lawsons Creek in the vicinity of the proposed Lawsons Creek Crossing. Figure 7.9 and Figure 7.10 show the corresponding peak velocities for the 10% (1 in 10) and 1% (1 in 100) AEP events respectively.

Flood maps showing design peak flood levels, depths and velocities in Lawsons Creek in the vicinity of the proposed Lawsons Creek Crossing for the 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMP design events at the above locations are provided in Appendix F.

The model results for this scenario indicate the following:

- The proposed road crossing would be overtopped during events equal to or greater than 10% AEP.
- For 10% AEP event, the predicted peak flood depths over the road are up to 0.5 m, while peak flood velocities over the road would be up to 4 m/s.
- For 1% AEP event, the predicted peak flood depths over the road are up to 1.2 m, while peak flood velocities over the road would be up to 6 m/s.
- For the PMF, the predicted peak flood depths over the road are up to 4 m.

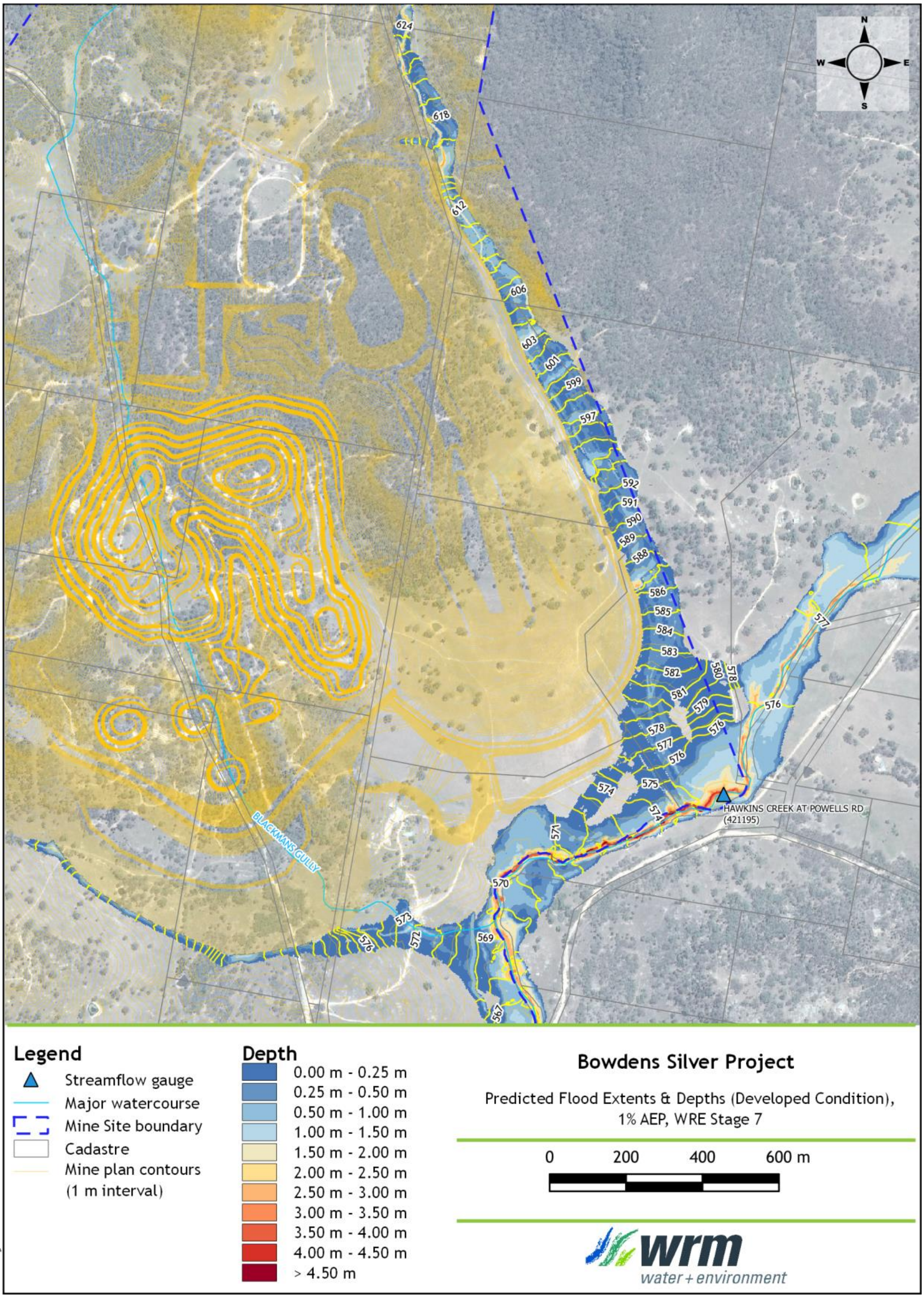


Figure 7.1 – 1% (1 in 100) AEP peak flood levels and depths in the vicinity of the proposed WRE - Maximum Disturbance Scenario

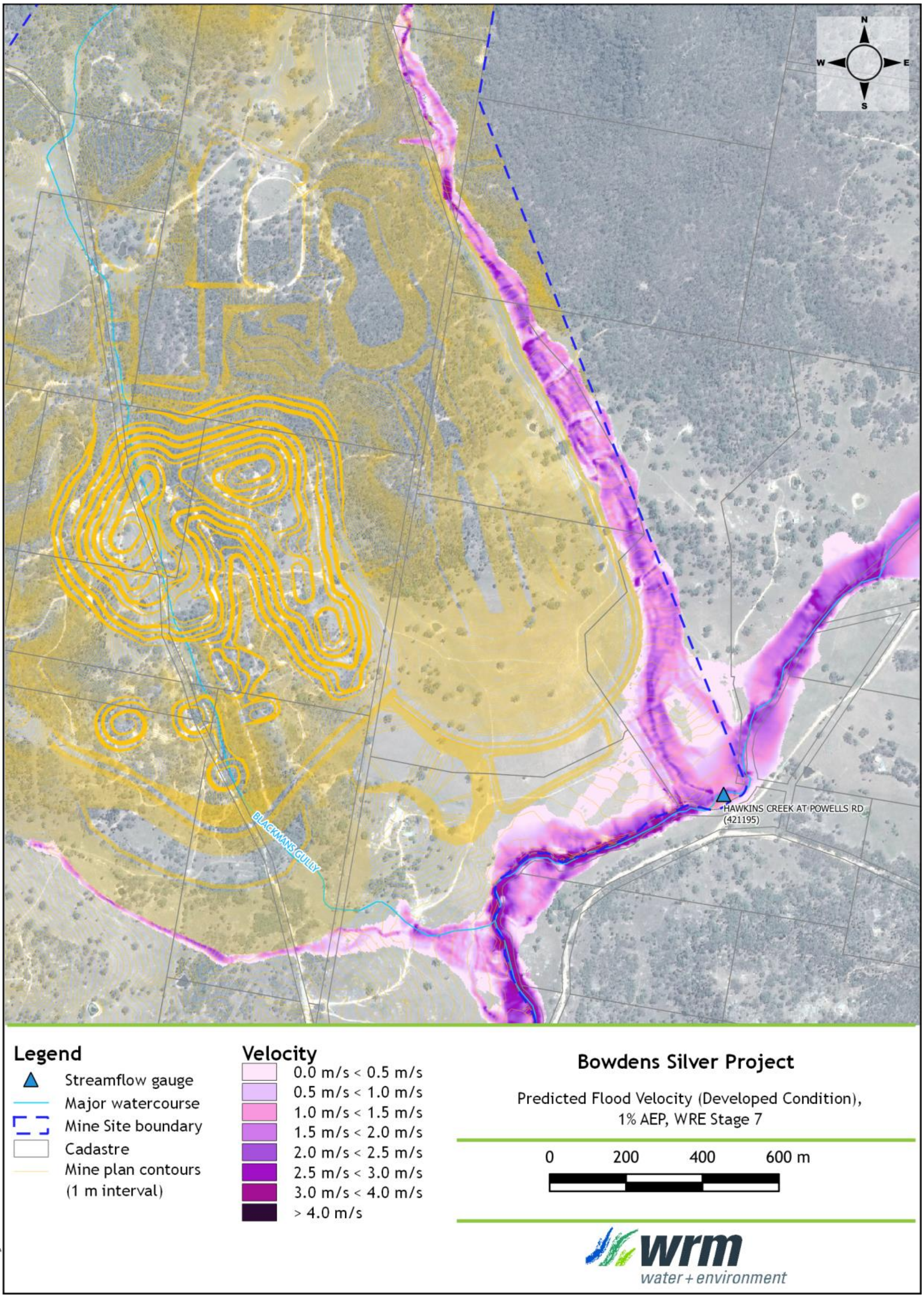


Figure 7.2 – 1% (1 in 100) AEP peak velocities in the vicinity of the proposed WRE - Maximum Disturbance Scenario

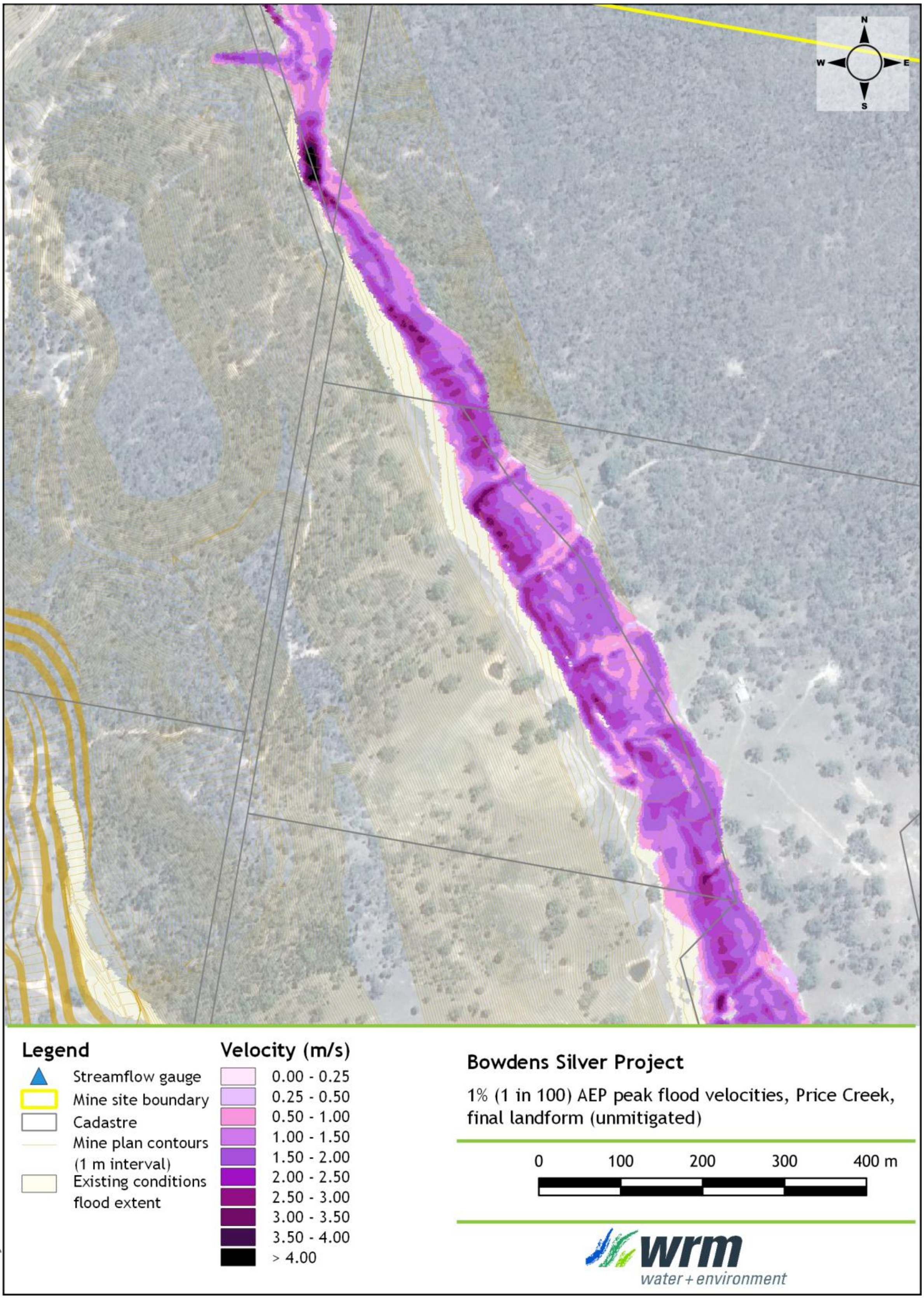


Figure 7.3 – 1% (1 in 100) AEP peak velocities along Price Creek adjacent to the proposed WRE - Maximum Disturbance Scenario

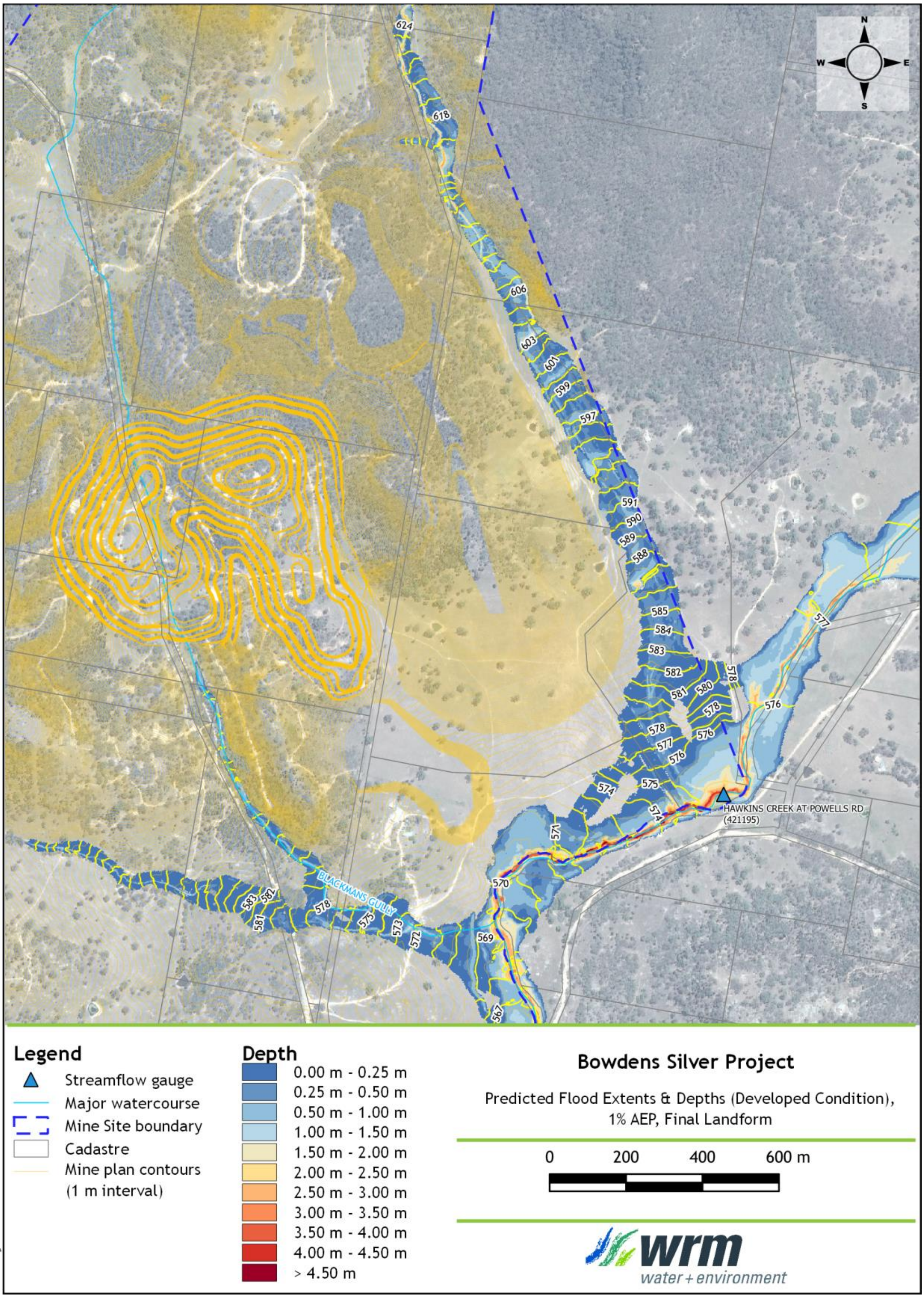


Figure 7.4 – 1% (1 in 100) AEP peak flood levels and depths in the vicinity of the proposed WRE – Final Landform Scenario

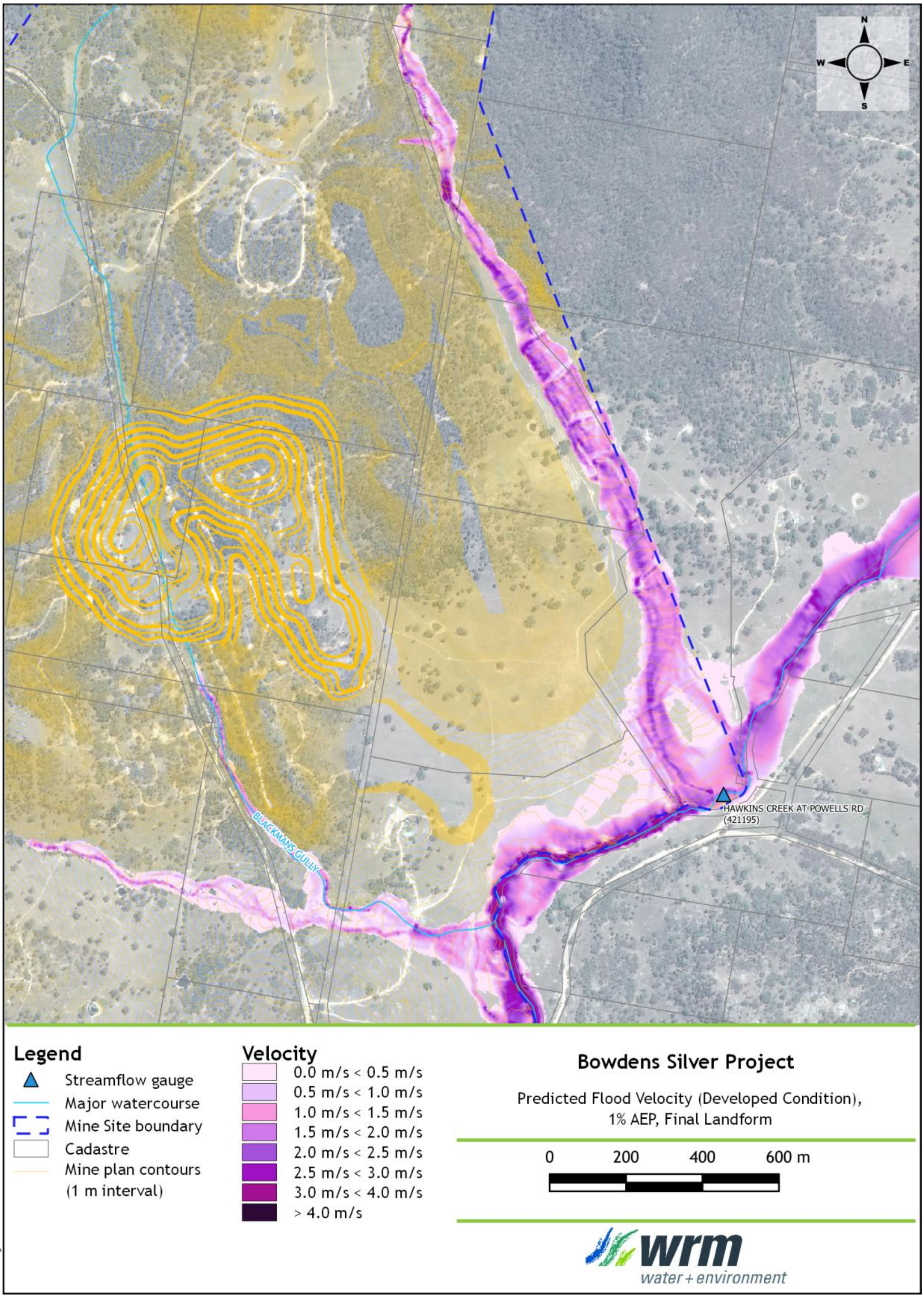


Figure 7.5 – 1% (1 in 100) AEP peak velocities in the vicinity of the proposed WRE – Final Landform Scenario

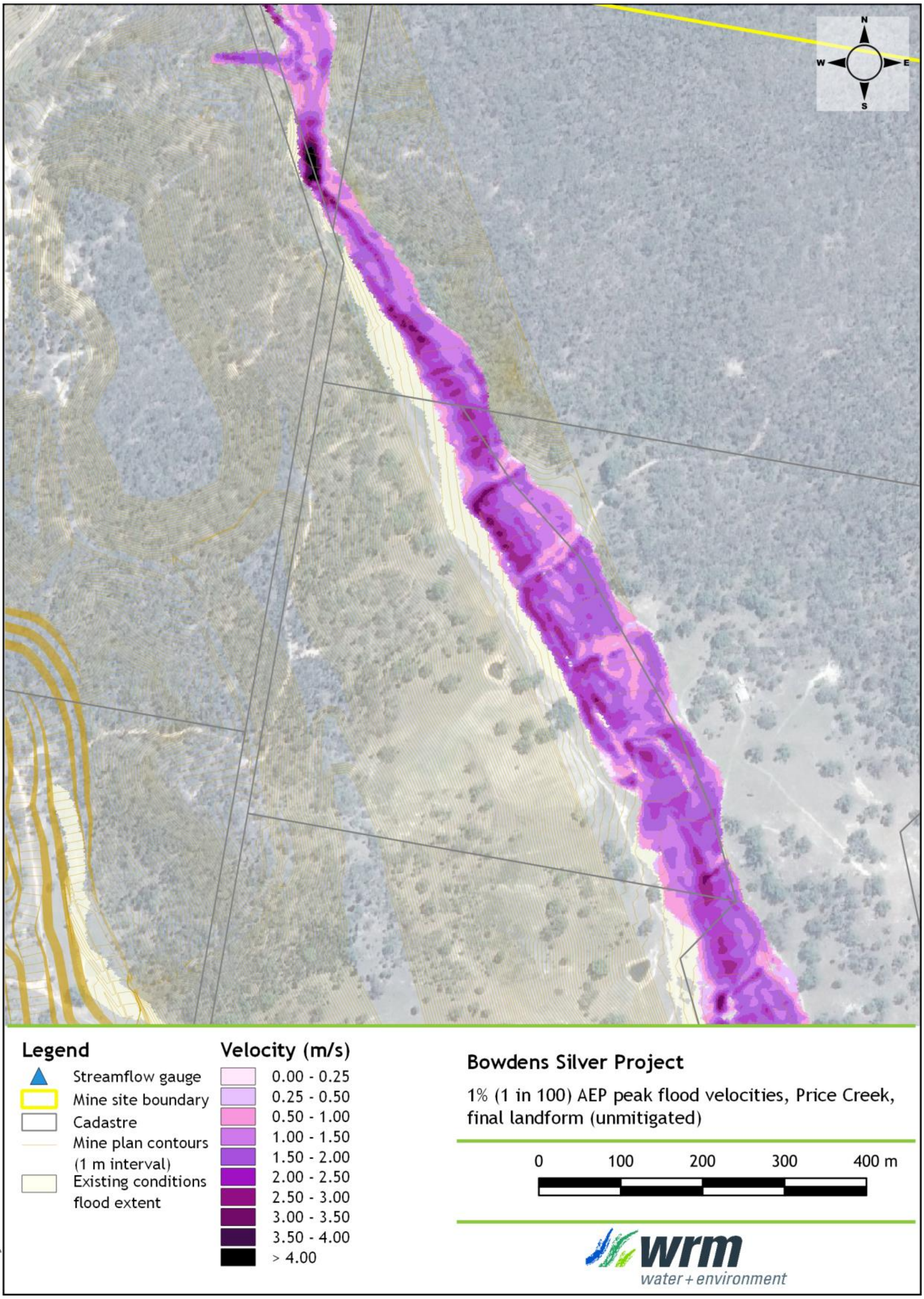


Figure 7.6 – 1% (1 in 100) AEP peak velocities along Price Creek adjacent to the proposed WRE – Final Landform Scenario

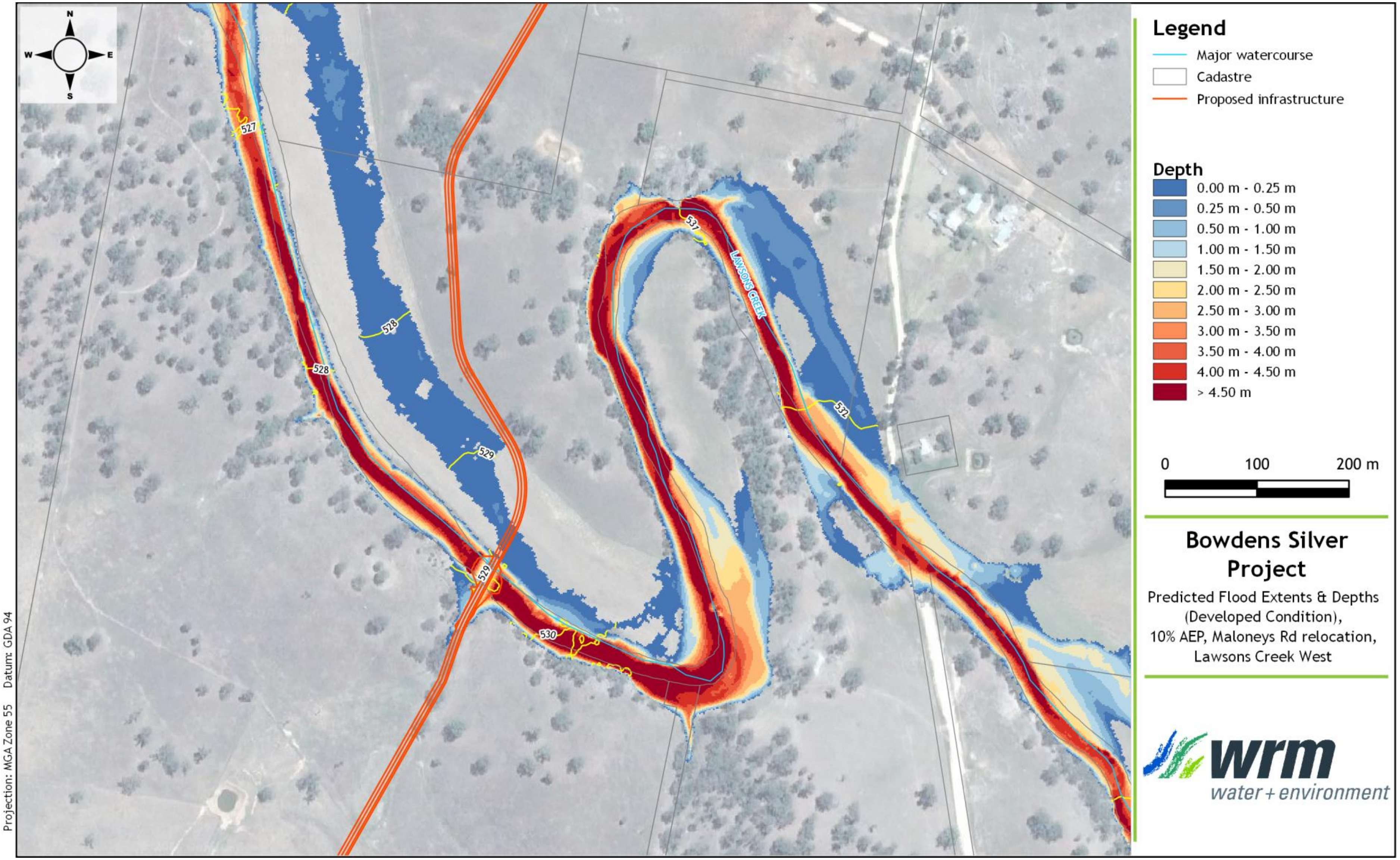


Figure 7.7 – 10% (1 in 10) AEP peak flood levels and depths along Lawsons Creek in the vicinity of the proposed Lawsons Creek Crossing – Lawsons Creek Crossing Scenario

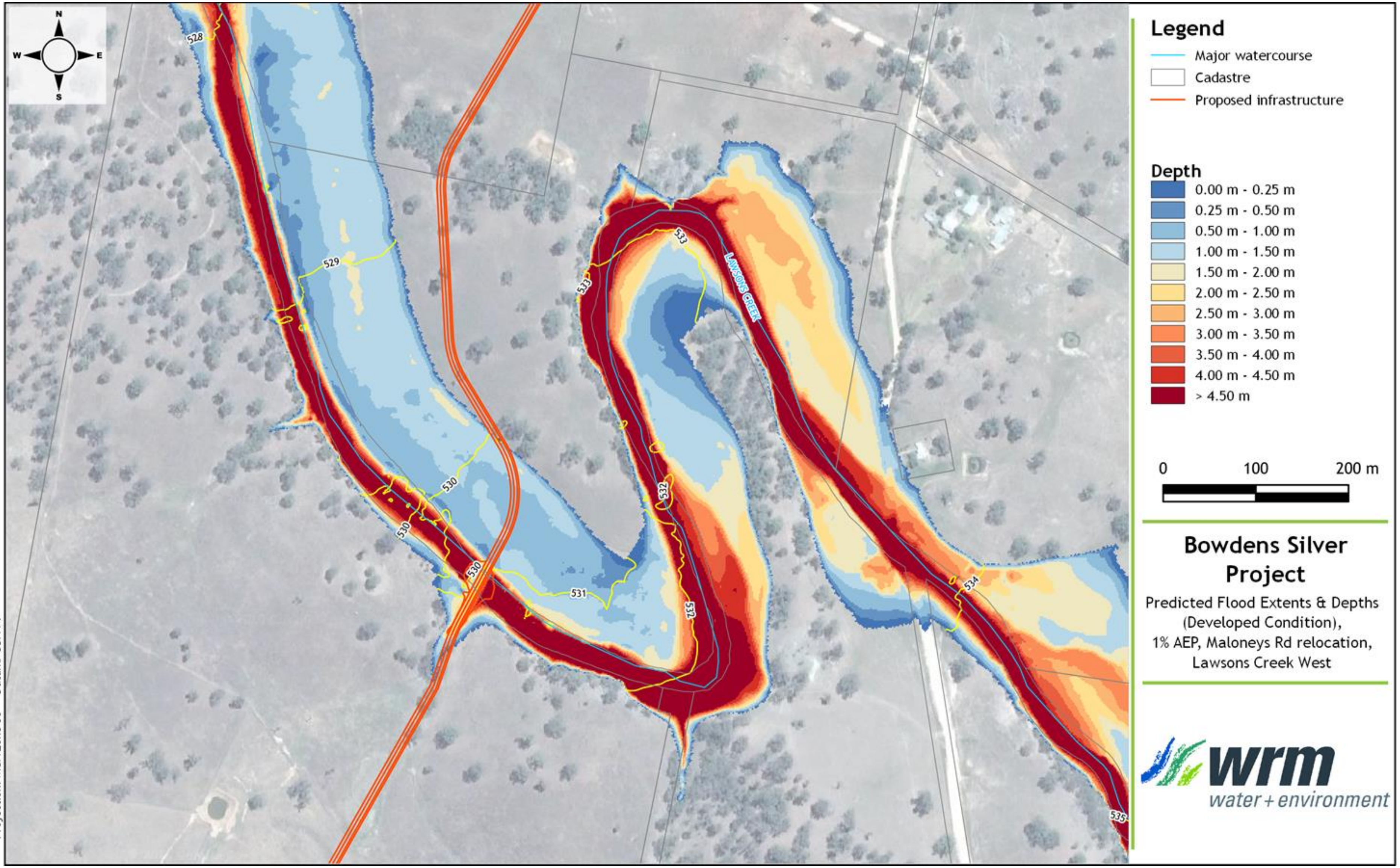


Figure 7.8 – 1% (1 in 100) AEP peak flood levels and depths along Lawsons Creek in the vicinity of the proposed Lawsons Creek Crossing – Lawsons Creek Crossing Scenario

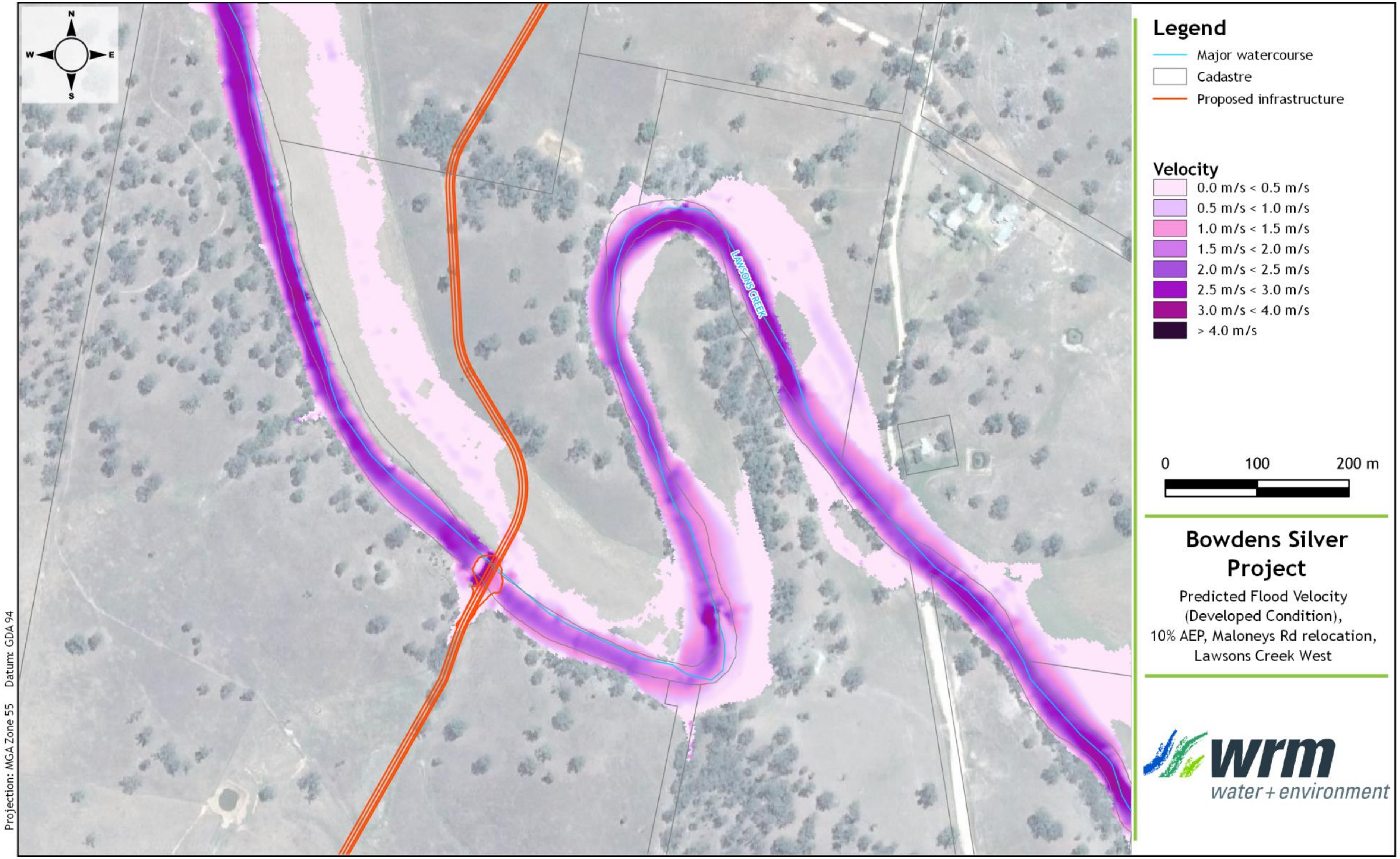


Figure 7.9 – 10% (1 in 10) AEP peak velocities along Lawsons Creek in the vicinity of the proposed Lawsons Creek Crossing – Lawsons Creek Crossing Scenario

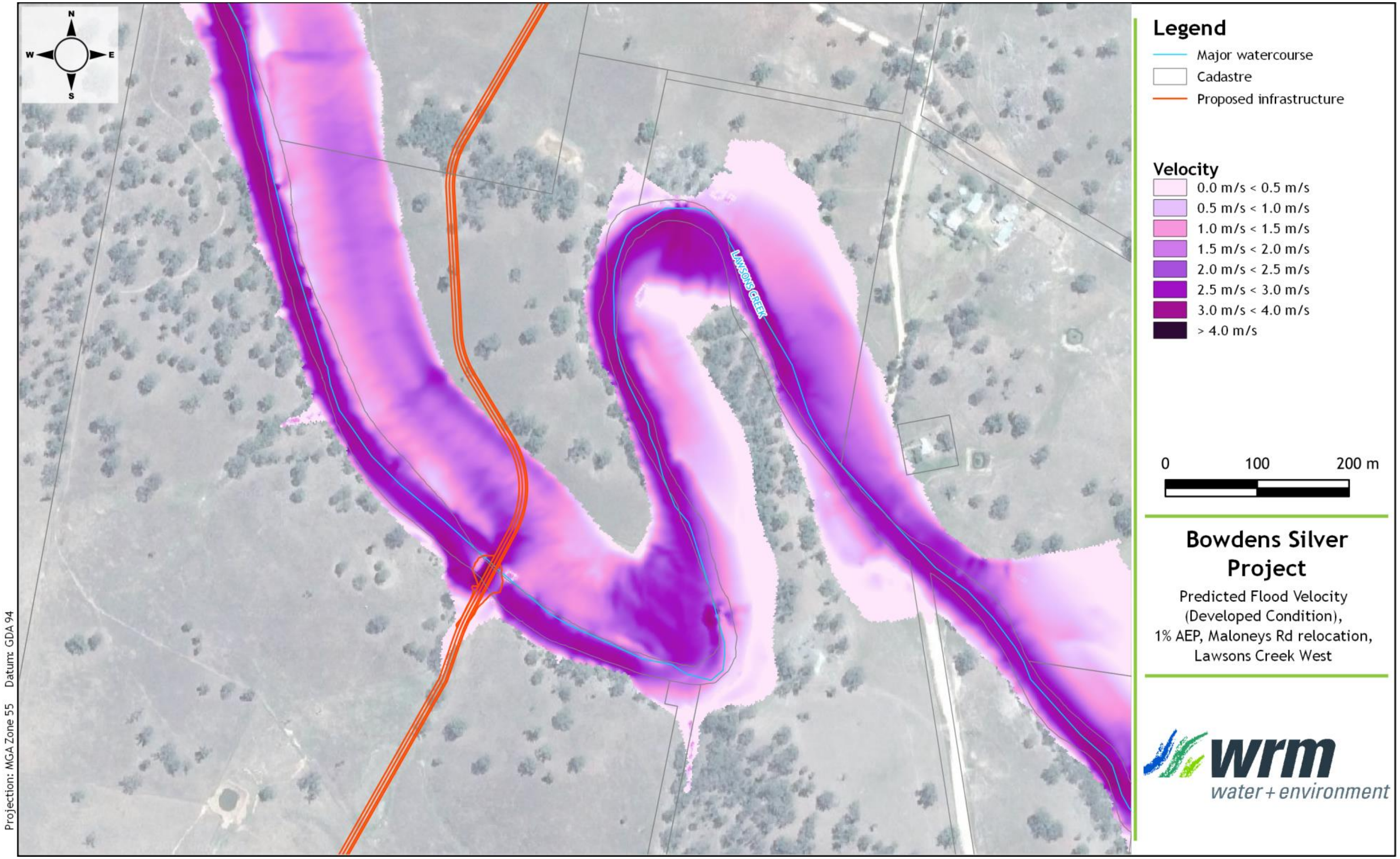


Figure 7.10 – 1% (1 in 100) AEP peak velocities along Lawsons Creek in the vicinity of the proposed Lawsons Creek Crossing – Lawsons Creek Crossing Scenario

7.3 HYDRAULIC IMPACTS

7.3.1 Maximum disturbance scenario

Flood maps showing the predicted impacts on peak flood levels and velocities in the vicinity of the proposed WRE for the Maximum Disturbance Scenario are shown in the following figures:

- Figure 7.11, Figure 7.12 and Figure 7.13 for the predicted impacts on peak flood levels for the 10% AEP, 1% AEP and 0.2% AEP events respectively; and
- Figure 7.14, Figure 7.15 and Figure 7.16 for the predicted impacts on peak velocities for the 10% AEP, 1% AEP and 0.2% AEP events respectively.

Additional flood maps showing the predicted impacts on peak flood levels and velocities under the Maximum Disturbance Scenario for the 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF design events are provided in Appendix D.

The model results indicate the following:

- There are generally no increases in peak flood levels and velocities in Price Creek upstream of the proposed WRE for all modelled events.
- Flood levels would be increased at number of locations in the Price Creek and Hawkins Creek channel and floodplain as described below:
  - Along the Price Creek floodplain adjacent to the WRE, there are predicted increases in peak flood levels of up to 0.3 m for the 10% AEP event, up to 0.4 m/s for the 1% AEP event and up to 0.5 m/s for the 0.2% AEP event. This is due to the proposed WRE forcing more water to flow along the eastern floodplain of Price Creek.
  - In Hawkins Creek, there would be minor increases in peak flood levels of up to 0.05 m for the 10% AEP event, up to 0.04 m for the 1% AEP event and up to 0.03 m for the 0.2% AEP event. These impacts dissipate to less than 0.01 m about 150 m upstream and downstream of the Bingmans Crossing stream gauge.
- Flood velocities would also be increased at number of locations in the Price Creek and Hawkins Creek channel and floodplain as described below:
  - There would be increases in peak velocities along the Price Creek floodplain of up to 1.8 m/s for the 10% AEP event and up to 1.1 m/s for the 1% and 0.2% AEP events. This is due to the proposed WRE forcing more water to flow along the eastern floodplain of Price Creek.
  - Just downstream of the constriction at the northeastern corner of the proposed WRE and haul road, there would be localised increases in peak velocities of up to 3.1 m/s for the 10% AEP event, up to 3.5 m/s for the 1% AEP event and up to 3.7 m/s for the 0.2% AEP event.
  - Along the eastern toe of the WRE and haul (along the western side of the Price Creek floodplain), there would be localised increases in peak velocities of up to 1.4 m/s, 1.1 m/s and 1.1 m/s for the 10%, 1% and 0.2% AEP events respectively.
  - There would be increases in peak velocities of up to 0.9 m/s for the 10%, up to 0.6 m/s for the 1% AEP event and up to 0.5 m/s for the 0.2% AEP event near the southeastern corner of the proposed WRE.
  - In the Hawkins Creek, there would be minor increases in peak velocities of up to 0.14 m/s for the 10% AEP event, up to 0.08 m/s for the 1% AEP event and up to 0.07 m/s for the 0.2% AEP event. These impacts dissipate to less than 0.01 /s about 550 m downstream of the Bingmans Crossing stream gauge.

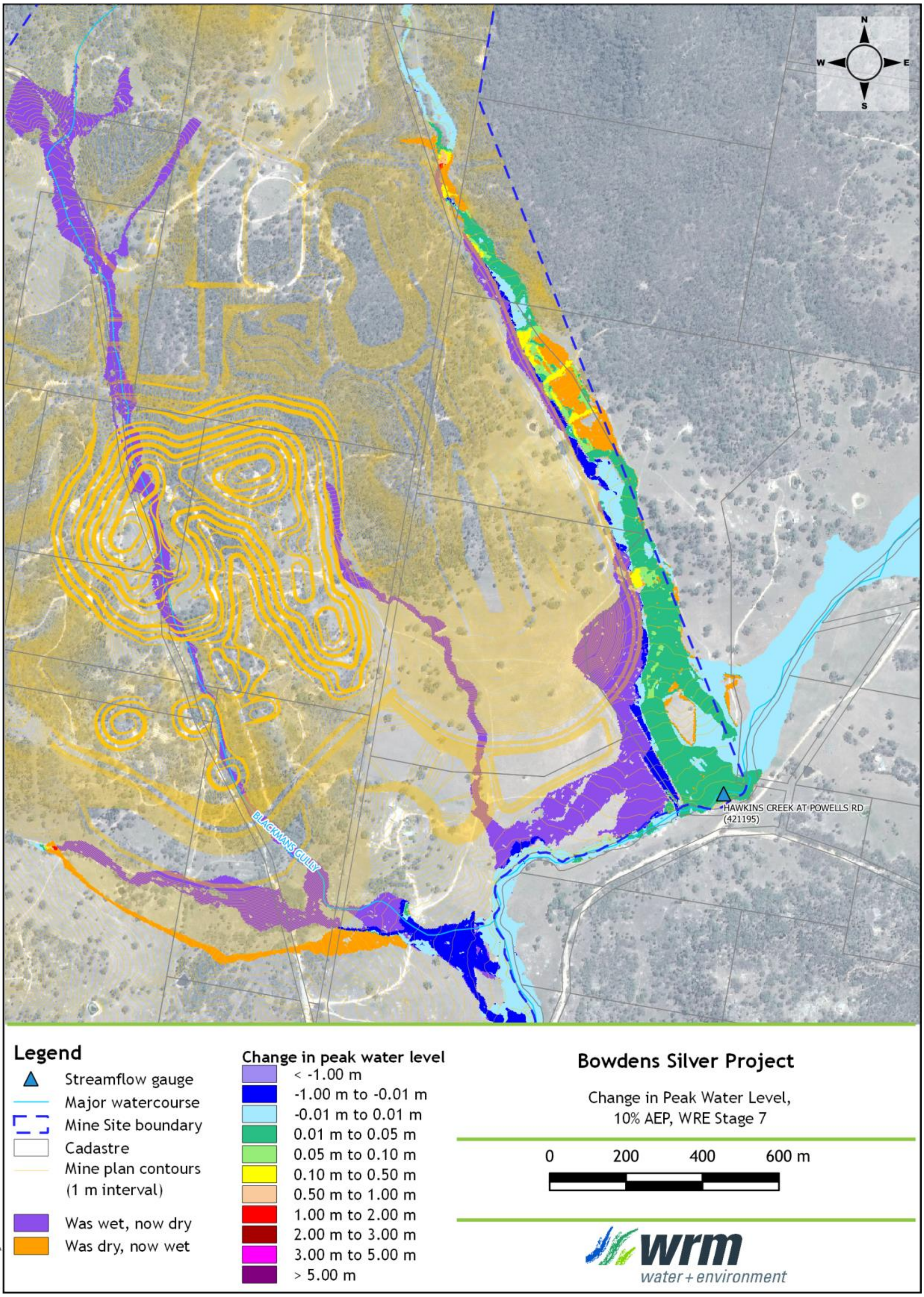


Figure 7.11 – 10% (1 in 10) AEP predicted impacts on peak flood levels along Price Creek adjacent to the proposed WRE – Maximum Disturbance Scenario

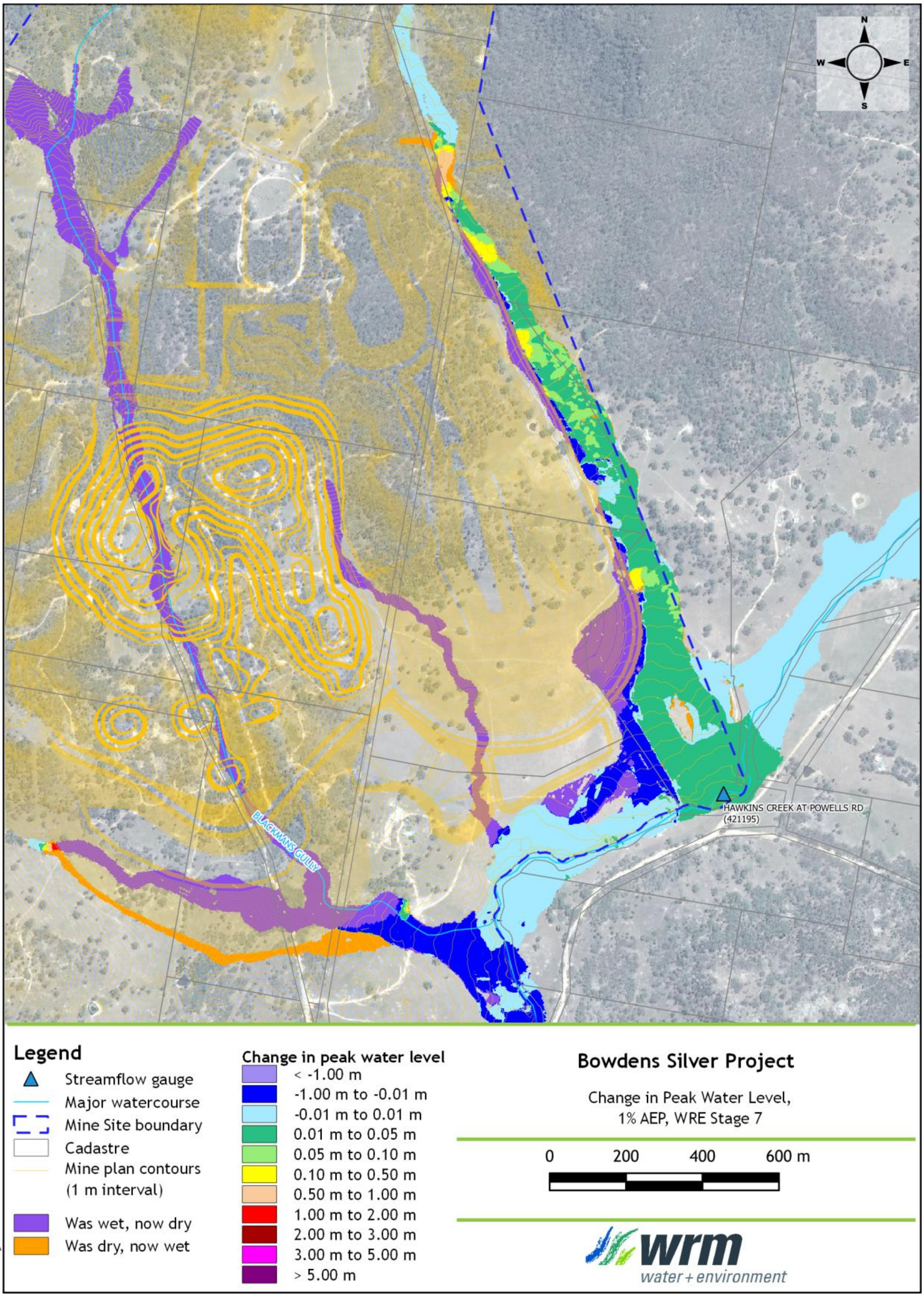


Figure 7.12 – 1% (1 in 100) AEP predicted impacts on peak flood levels along Price Creek adjacent to the proposed WRE – Maximum Disturbance Scenario

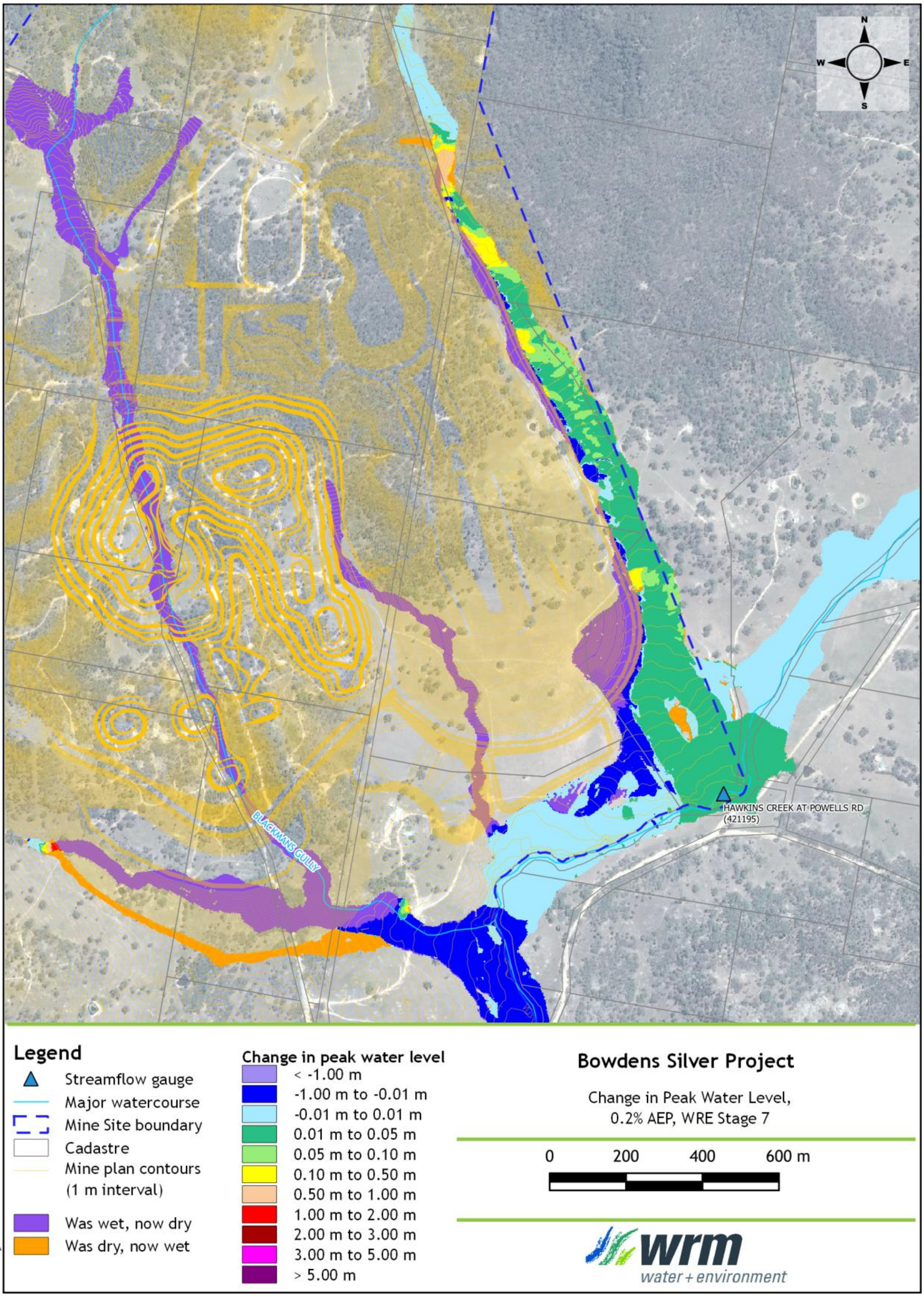


Figure 7.13 – 0.2% (1 in 500) AEP predicted impacts on peak flood levels along Price Creek adjacent to the proposed WRE – Maximum Disturbance Scenario

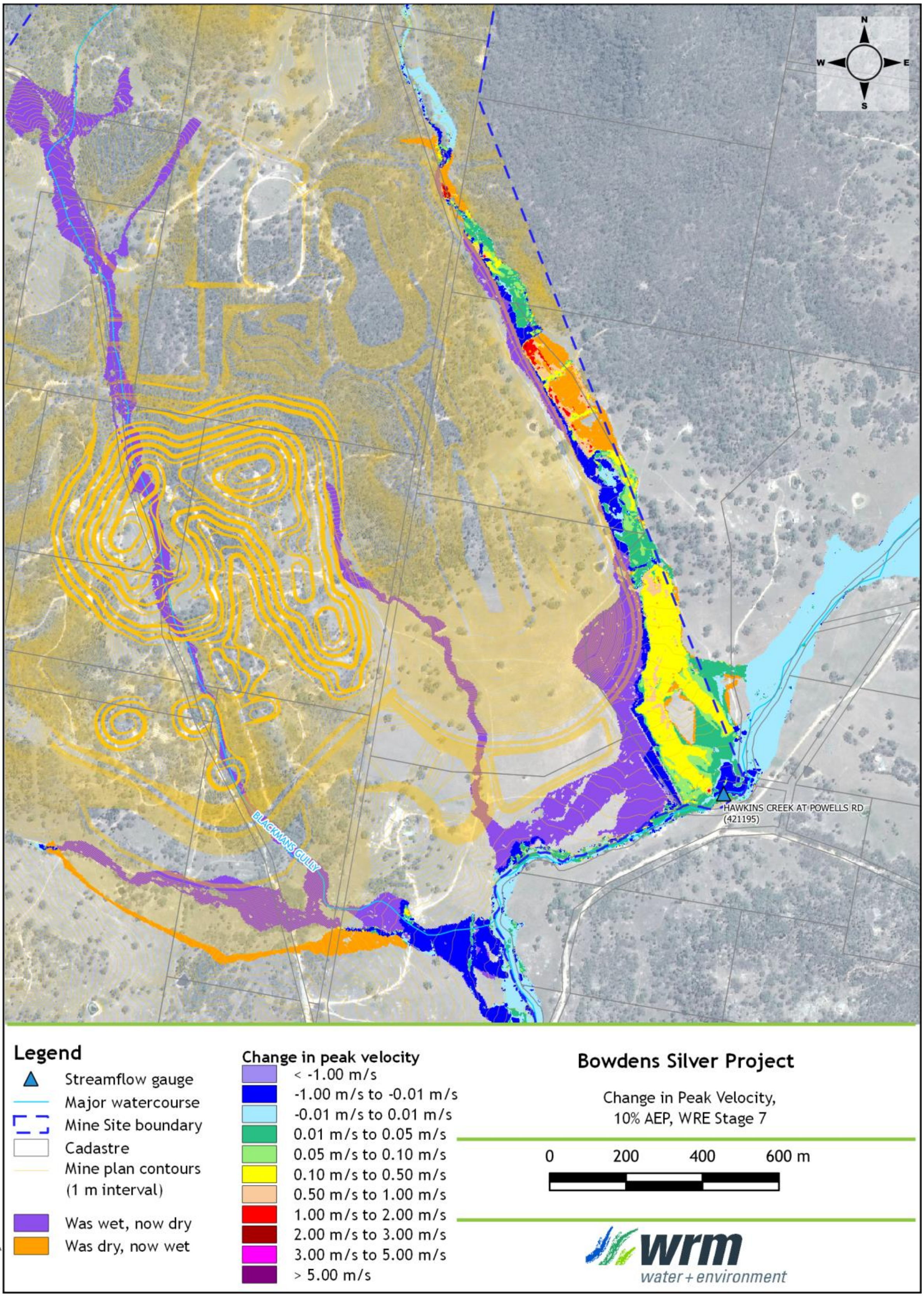


Figure 7.14 – 10% (1 in 10) AEP predicted impacts on peak velocities along Price Creek adjacent to the proposed WRE – Maximum Disturbance Scenario

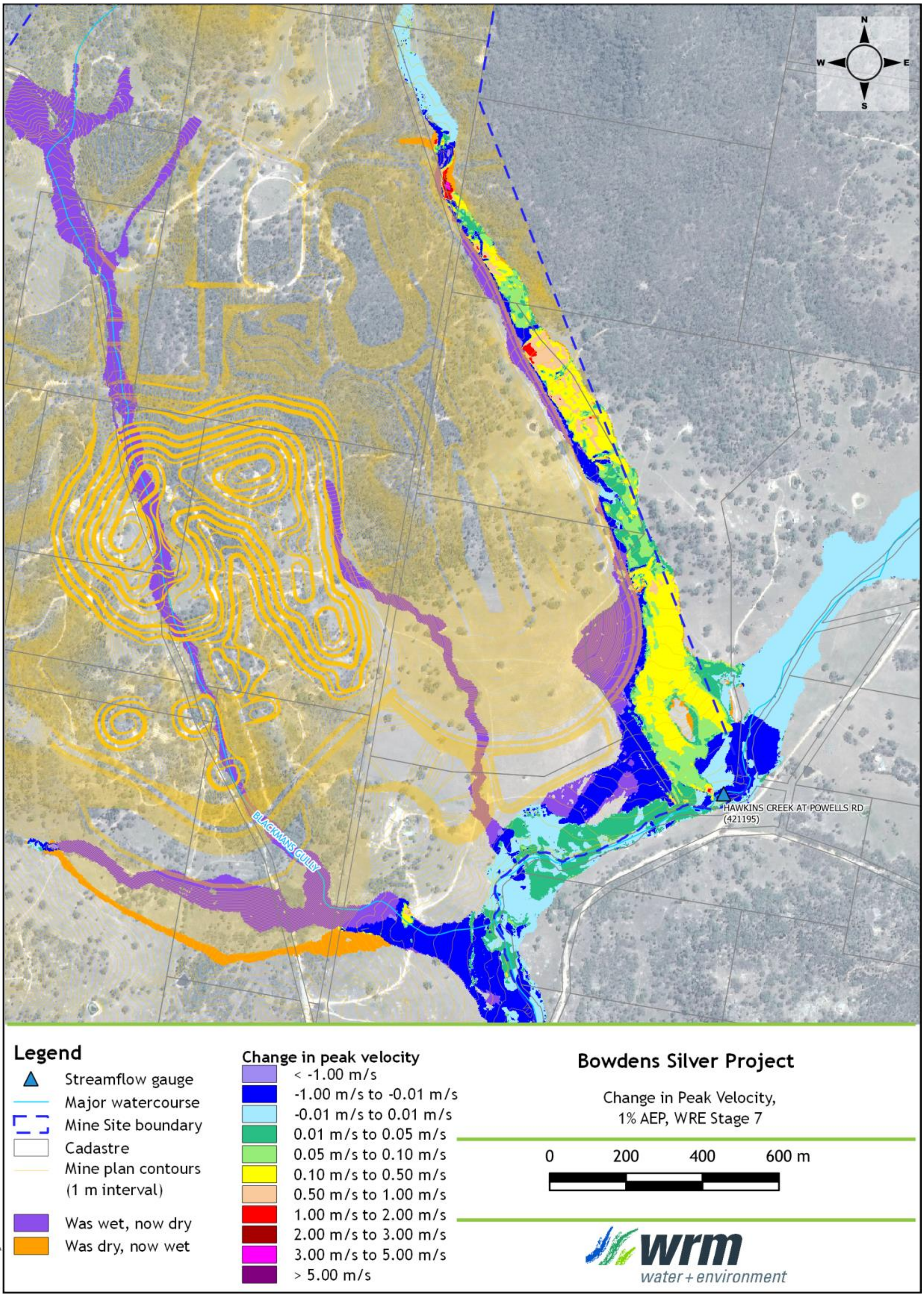


Figure 7.15 – 1% (1 in 100) AEP predicted impacts on peak velocities along Price Creek adjacent to the proposed WRE – Maximum Disturbance Scenario

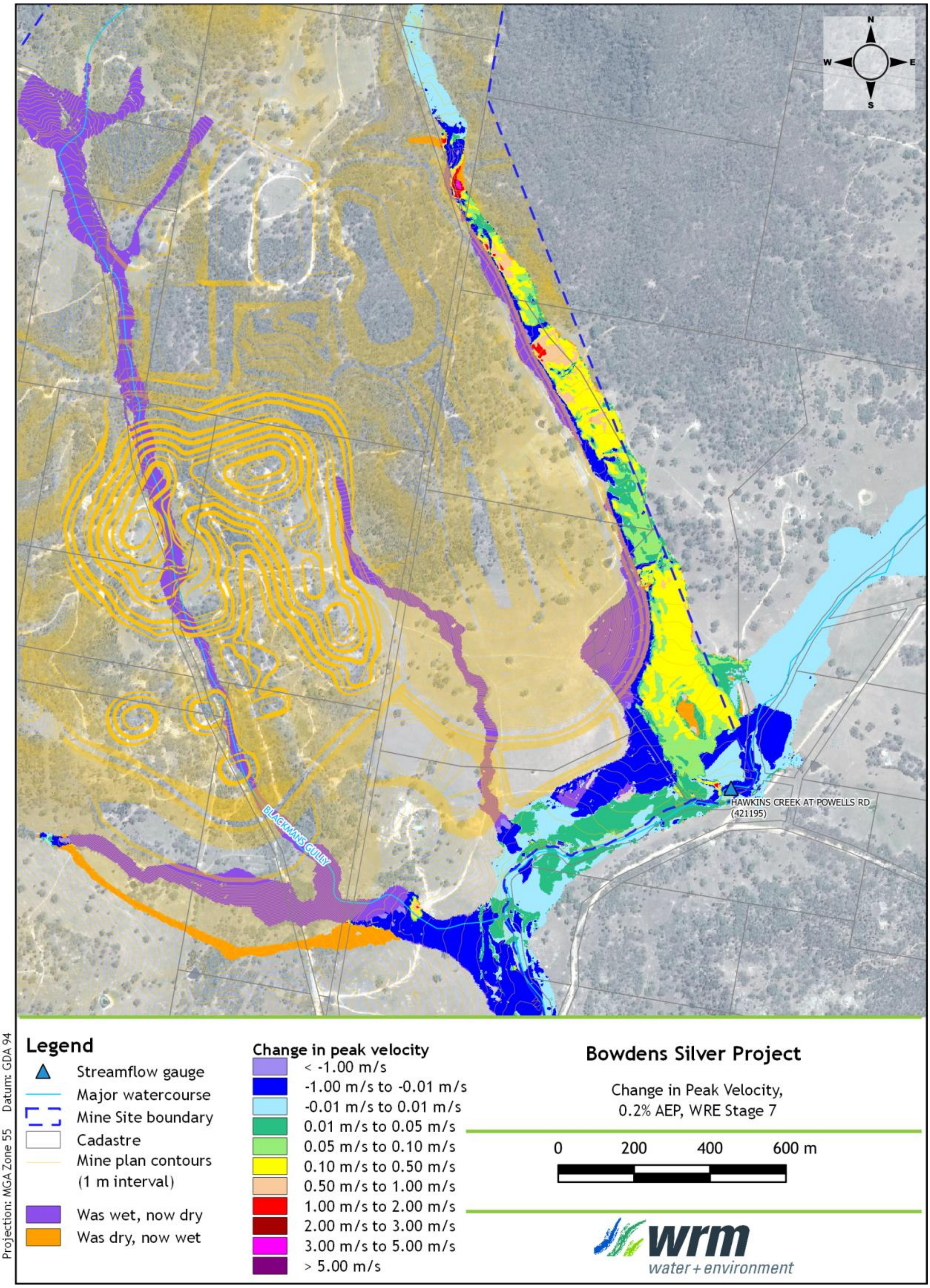


Figure 7.16 – 0.2% (1 in 500) AEP predicted impacts on peak velocities along Price Creek adjacent to the proposed WRE – Maximum Disturbance Scenario

7.3.2 Final landform scenario

Flood maps showing the predicted impacts on peak flood levels and velocities in the vicinity of the proposed WRE for the Final Landform Scenario are shown in the following figures:

- Figure 7.17, Figure 7.18 and Figure 7.19 for the predicted impacts on peak flood levels for the 10% AEP, 1% AEP and 0.2% AEP events respectively; and
- Figure 7.20, Figure 7.21 and Figure 7.22 for the predicted impacts on peak velocities for the 10% AEP, 1% AEP and 0.2% AEP events respectively.

Additional flood maps showing the predicted impacts on peak flood levels and velocities under the Final Landform Scenario for the 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF design events are provided in Appendix E.

- The predicted impacts for the Final Landform Scenario are generally similar to those observed for the Maximum Disturbance Scenario.
- There are generally no increases in peak flood levels and velocities in Price Creek upstream of the proposed WRE for all modelled events.
- Flood levels would be increased at number of locations in the Price Creek and Hawkins Creek channel and floodplain as described below:
  - Along the Price Creek floodplain adjacent to the WRE, there are predicted increases in peak flood levels of up to 0.3 m for the 10% AEP event, up to 0.4 m/s for the 1% AEP event and up to 0.5 m/s for the 0.2% AEP event. This is due to the proposed WRE forcing more water to flow along the eastern floodplain of Price Creek.
  - In Hawkins Creek, there would be minor increases in peak flood levels of up to 0.05 m for the 10% AEP event, up to 0.03 m for the 1% AEP event and up to 0.03 m for the 0.2% AEP event. These impacts dissipate to less than 0.01 m about 150 m upstream and downstream of the Bingmans Crossing stream gauge.
- Flood velocities would also be increased at number of locations in the Price Creek and Hawkins Creek channel and floodplain as described below:
  - There would be increases in peak velocities along the Price Creek floodplain of up to 1.8 m/s for the 10% AEP event and up to 3.2 m/s for the 1% and 0.2% AEP events. This is due to the WRE forcing more water to flow along the eastern floodplain of Price Creek.
  - Just downstream of the constriction at the northeastern corner of the proposed WRE and haul road, there would be localised increases in peak velocities of up to 2.7 m/s for the 10% AEP event, up to 4.5 m/s for the 1% AEP event and up to 5.2 m/s for the 0.2% AEP event.
  - Along the eastern toe of the WRE and haul (along the western side of the Price Creek floodplain), there would be localised increases in peak velocities of up to 1.7 m/s, 3.1 m/s and 3.6 m/s for the 10%, 1% and 0.2% AEP events respectively.
  - There would be increases in peak velocities of up to 0.8 m/s for the 10% AEP event, up to 2.4 m/s for the 1% AEP event and up to 2.7 m/s for the 0.2% AEP event near the southeastern corner of the proposed WRE.
  - In the Hawkins Creek, there would be minor increases in peak velocities of up to 0.2 m/s for the 10% AEP event and up to 0.08 m/s for the 1% AEP and up to 0.2% AEP events. These impacts dissipate to less than 0.01 /s about 550 m downstream of the Bingmans Crossing stream gauge.

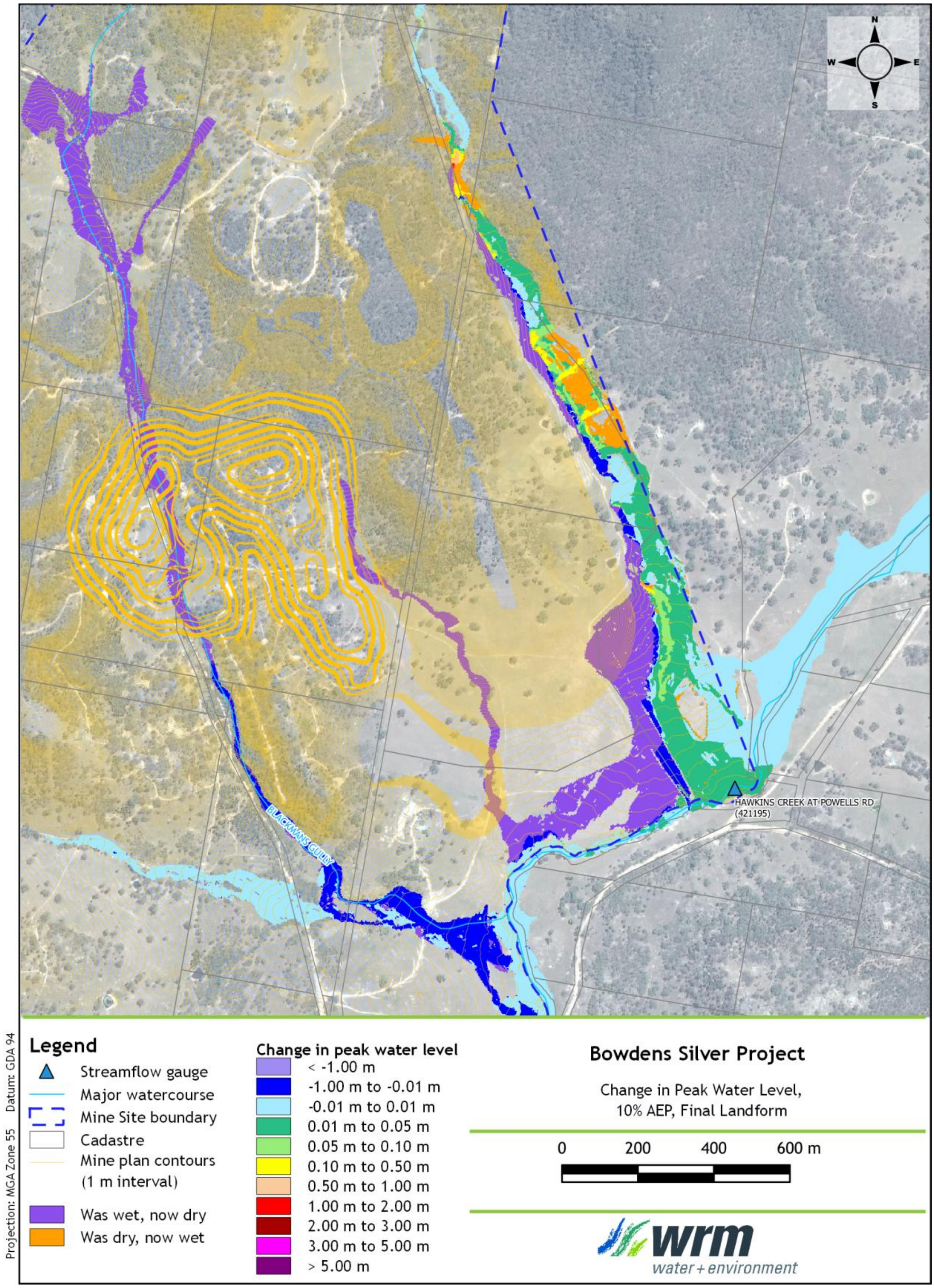


Figure 7.17 – 10% (1 in 10) AEP predicted impacts on peak flood levels along Price Creek adjacent to the proposed WRE – Final Landform Scenario

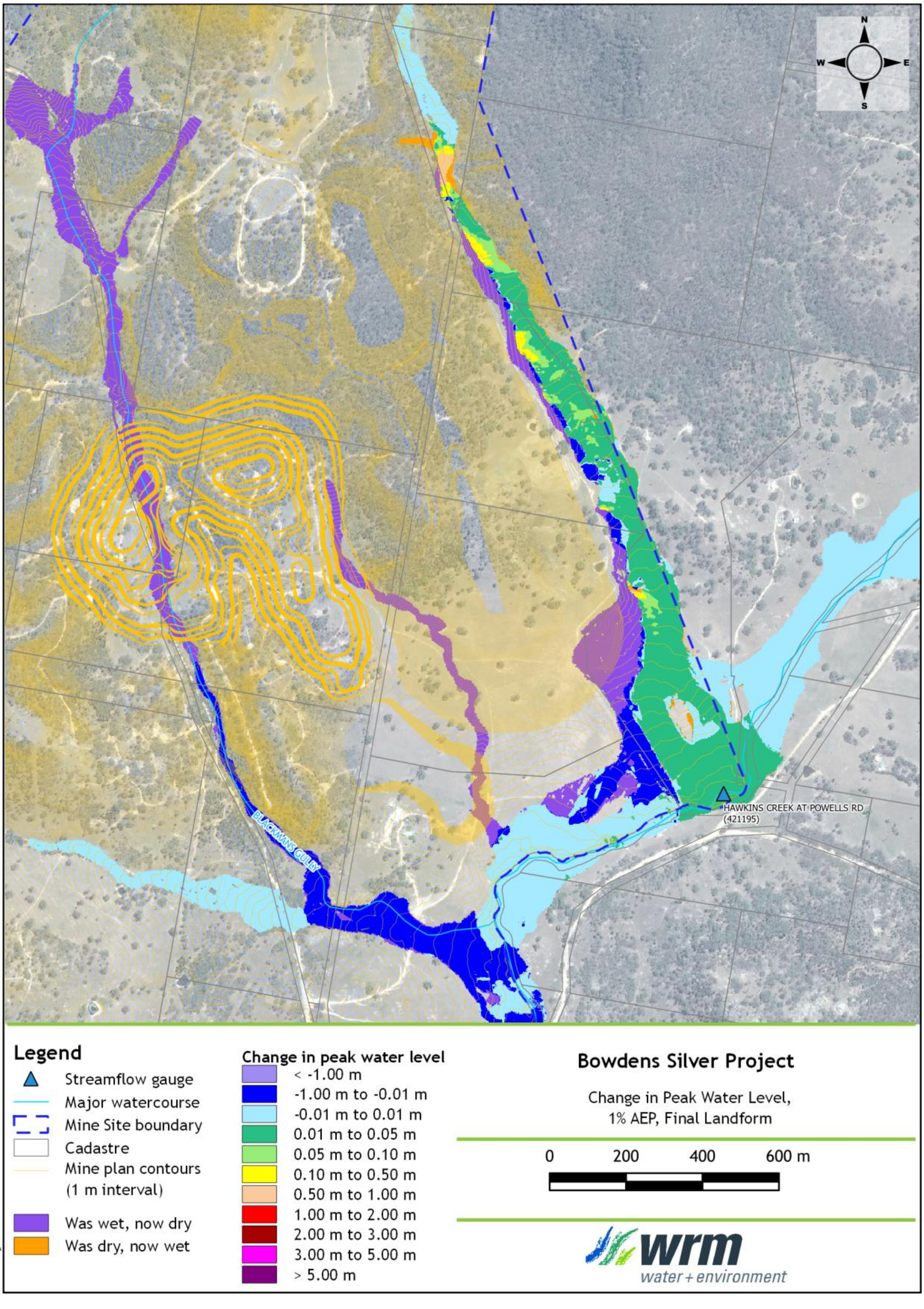


Figure 7.18 – 1% (1 in 100) AEP predicted impacts on peak flood levels along Price Creek adjacent to the proposed WRE – Final Landform Scenario

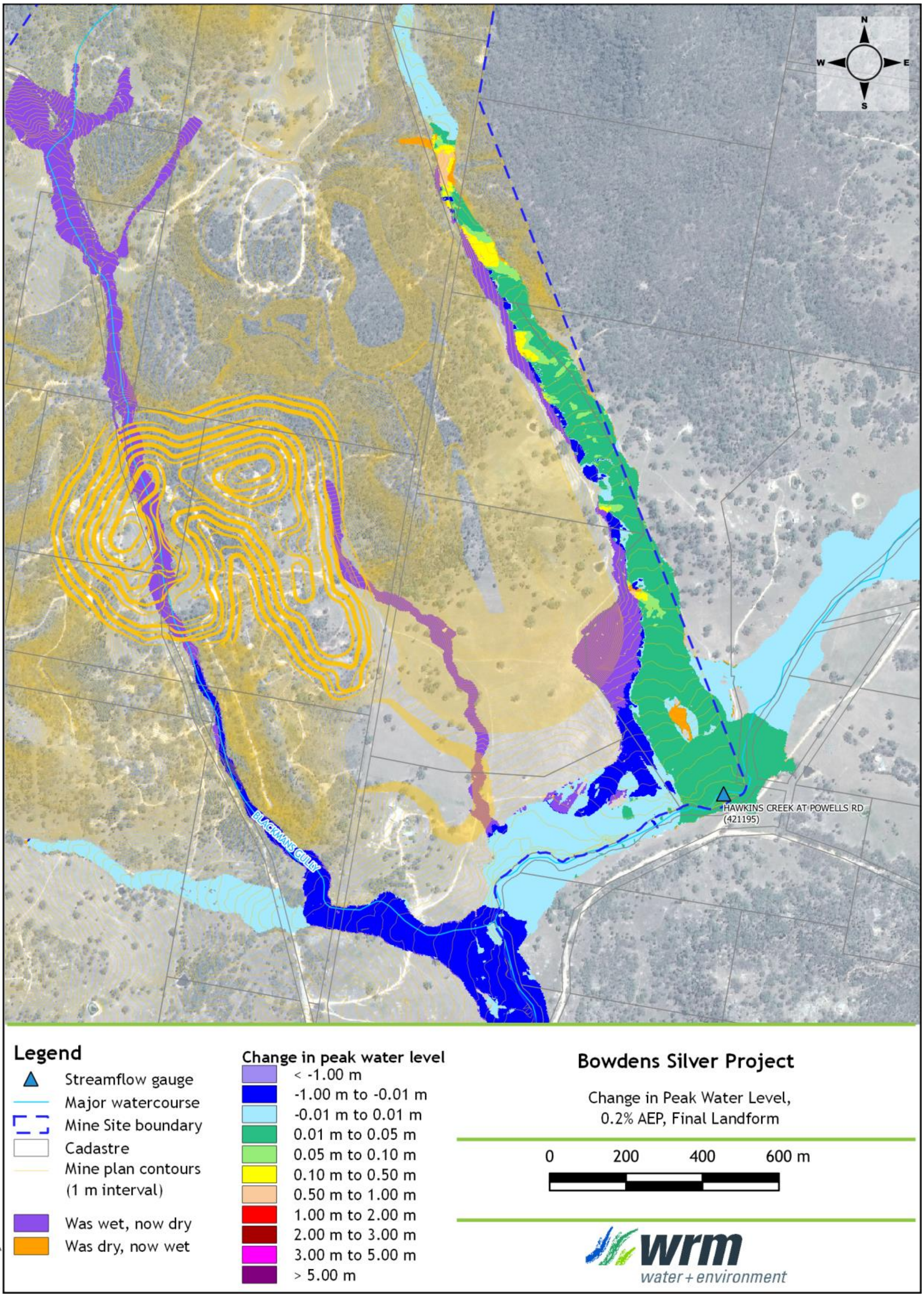


Figure 7.19 – 0.2% (1 in 500) AEP predicted impacts on peak flood levels along Price Creek adjacent to the proposed WRE – Final Landform Scenario

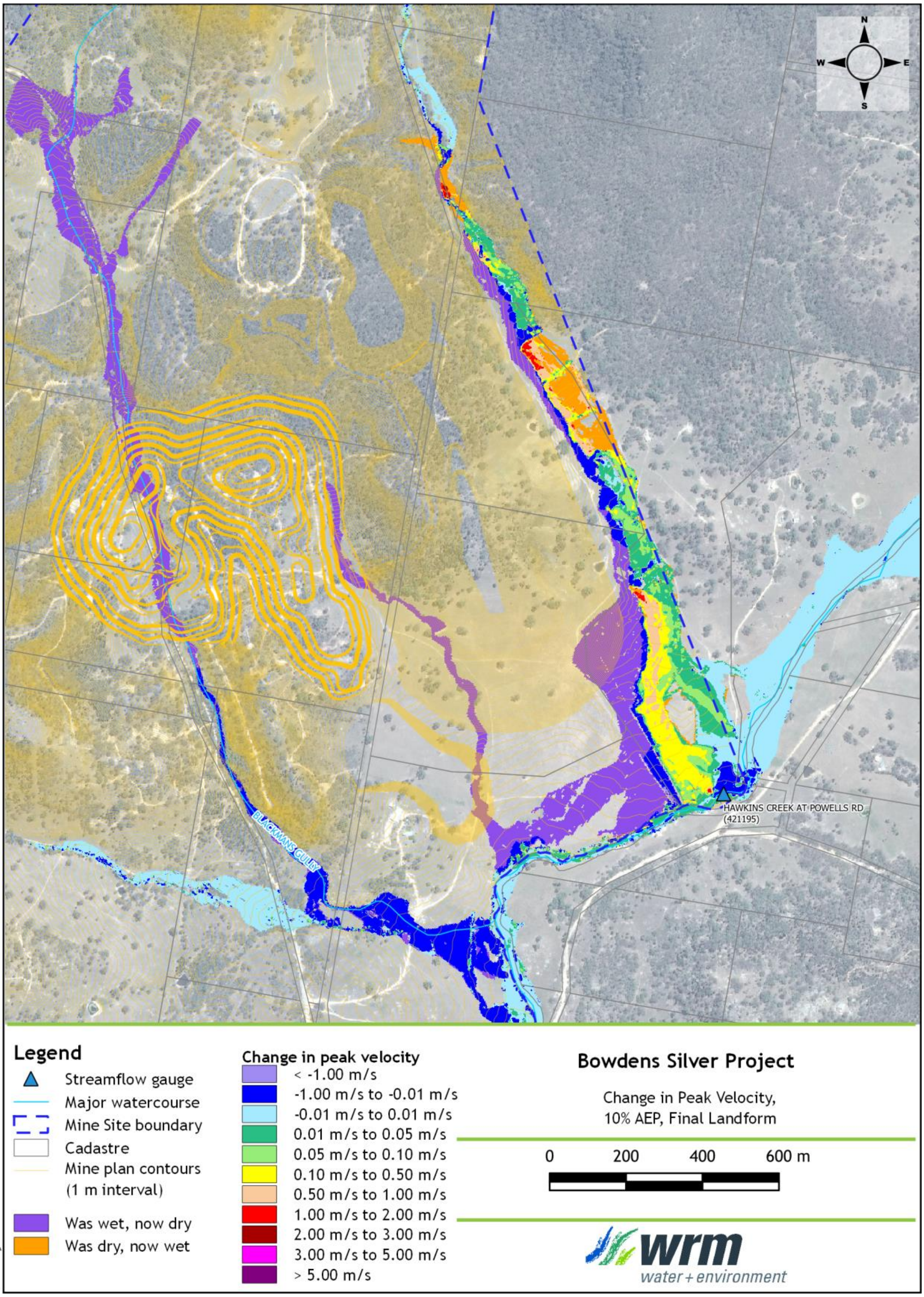


Figure 7.20 – 10% (1 in 10) AEP predicted impacts on peak velocities along Price Creek adjacent to the proposed WRE – Final Landform Scenario

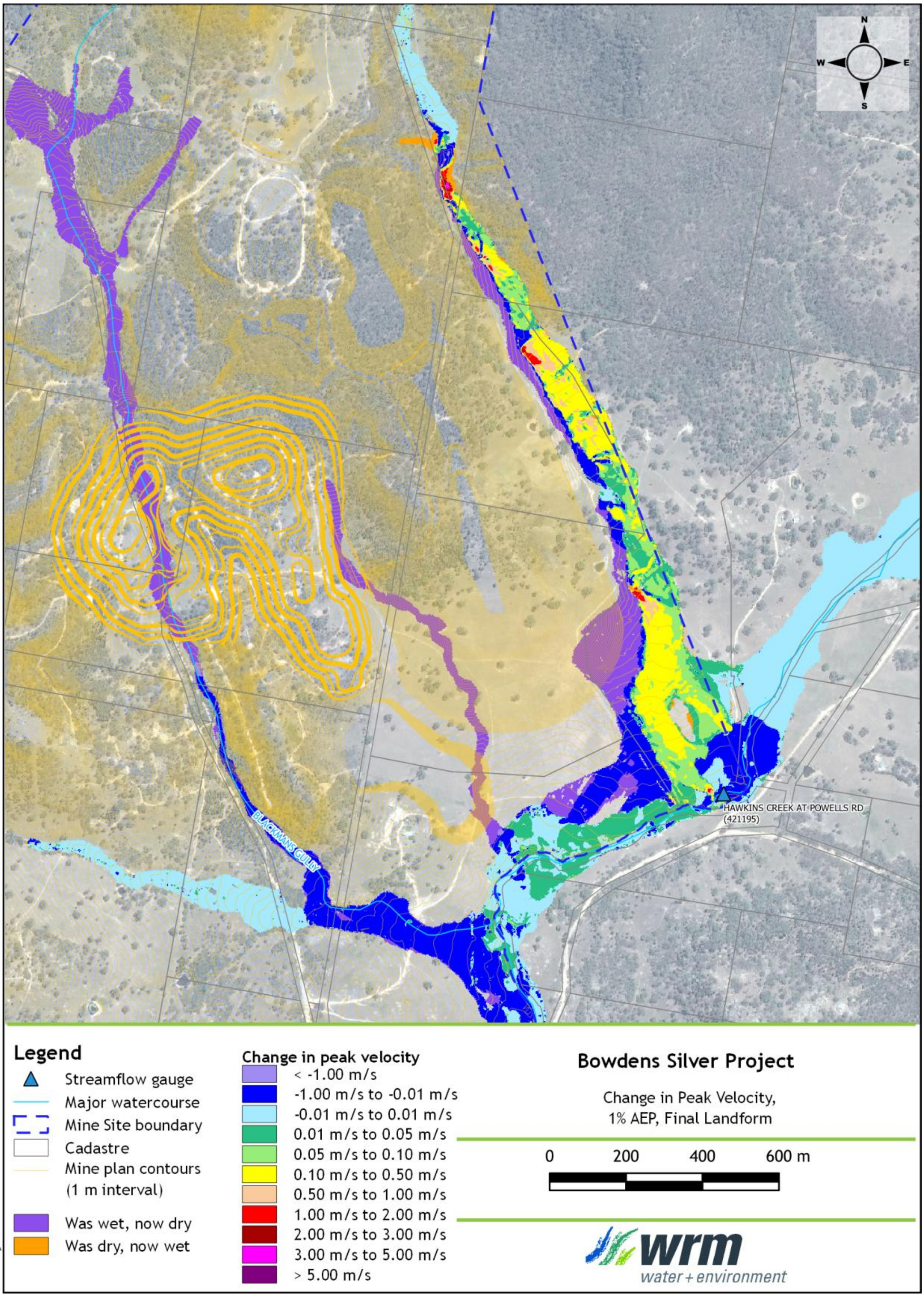


Figure 7.21 – 1% (1 in 100) AEP predicted impacts on peak velocities along Price Creek adjacent to the proposed WRE – Final Landform Scenario

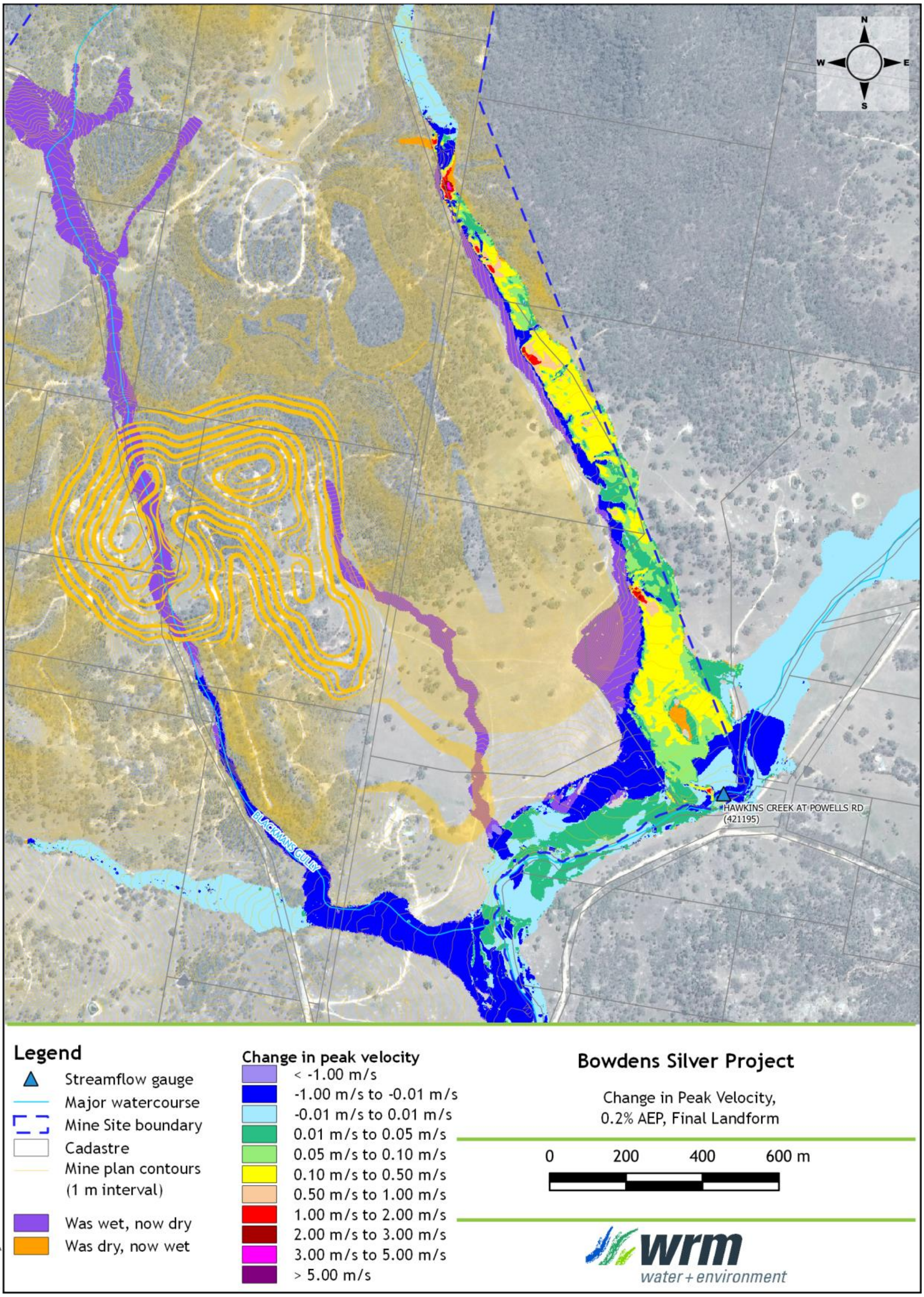


Figure 7.22 – 0.2% (1 in 500) AEP predicted impacts on peak velocities along Price Creek adjacent to the proposed WRE – Final Landform Scenario

7.3.3 Lawsons Creek crossing

Flood maps showing the predicted impacts on peak flood levels and velocities in the vicinity of the proposed Lawsons Creek Crossing for the Lawsons Creek Crossing scenario are shown in the following figures:

- Figure 7.23, Figure 7.24 and Figure 7.25 for the predicted impacts on peak flood levels for the 10% AEP, 1% AEP and 0.2% AEP events respectively; and
- Figure 7.26, Figure 7.27 and Figure 7.28 for the predicted impacts on peak velocities for the 10% AEP, 1% AEP and 0.2% AEP events respectively.

Additional flood maps showing the predicted impacts on peak flood levels and velocities for the Lawsons Creek Scenario for the 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF design events are provided in Appendix F.

The model results indicate the following:

- The proposed road crossing would increase peak flood levels upstream of the road:
  - For the 10% AEP event, peak flood levels would increase by up to 1.4 m. These impacts decrease in magnitude further away from the road crossing, dissipating to less than 0.01 m approximately 1.4 km upstream of the crossing.
  - The predicted increase in peak flood levels upstream of the crossing for the 10% AEP event would cause flows in Lawsons Creek to overtop the northern creek bank immediately upstream of the crossing. These overflows would drain to the northwest parallel to the Lawsons Creek before re-joining Lawsons Creek about 680 m downstream of the proposed crossing. These overflows would not occur under existing conditions for the 10% AEP event, but it would occur for larger events.
  - For the 1% AEP event, peak flood levels would increase by up to 1.4 m. These impacts decrease in magnitude further away from the road crossing, dissipating to less than 0.01 m approximately 700 m upstream of the crossing.
  - For the 0.2% AEP event, peak flood levels would increase by up to 1.8 m. These impacts decrease in magnitude further away from the road crossing, dissipating to less than 0.01 m approximately 700 m upstream of the crossing.
- There are predicted reductions in peak flood levels of up to 0.03 m downstream of the Lawsons Creek crossing for the 10% AEP event. However, peak flood levels would increase downstream of the crossing for the 1% and 0.2% AEP events:
  - For the 1% AEP event, peak flood levels would increase by up to 0.5 m. These impacts decrease in magnitude further away from the road crossing, dissipating to less than 0.01 m approximately 750 m downstream of the crossing.
  - For the 0.2% AEP event, peak flood levels would increase by up to 0.5 m. These impacts decrease in magnitude further away from the road crossing, dissipating to less than 0.01 m approximately 550 m downstream of the crossing.
- The proposed road crossing would reduce peak velocities in the Lawsons Creek channel. However, peak velocities would increase along the northern Lawsons Creek floodplain downstream of the crossing. This is due to the proposed crossing forcing water to flow to the northern bank of Lawsons Creek. For the 0.2% and 1% AEP events, velocities on the northern bank of Lawsons Creek would increase by up to 0.55 m/s, dissipating to less than 0.05 m/s approximately 800 m downstream of the crossing.
- The predicted increases in peak flood levels, extents and velocities do not appear to affect any existing dwellings for all events up to and including 0.2% (1 in 500) AEP. It is noted that all increases in flood levels, as the result of the relocated Maloneys Road (Pyangle Road) crossing of Lawsons Creek, would occur on land either owned or under an acquisition agreement with Bowdens Silver.

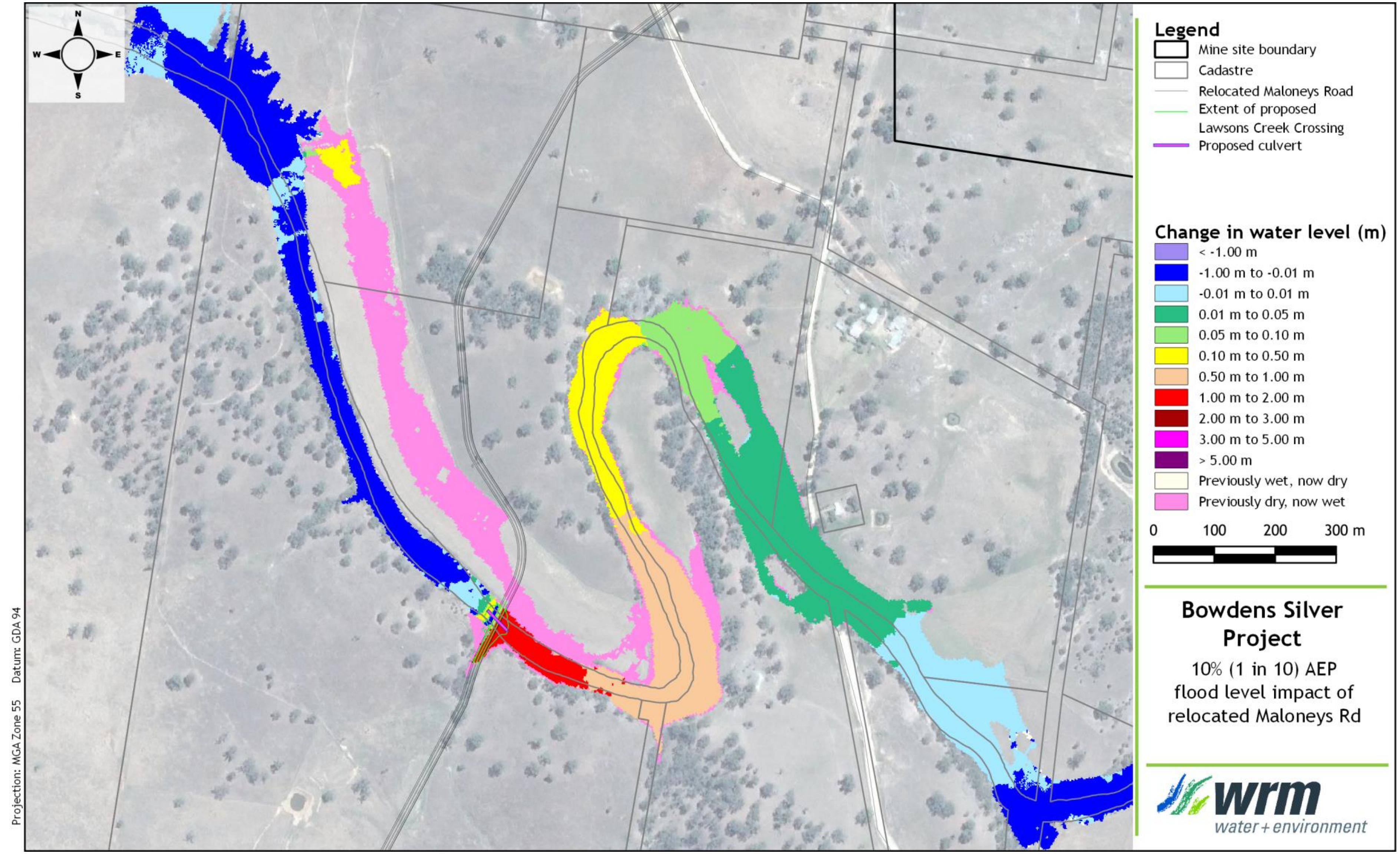


Figure 7.23 – 10% (1 in 10) AEP predicted impacts on peak flood levels along Lawsons Creek in the vicinity of the proposed Lawsons Creek Crossing – Lawsons Creek Crossing Scenario

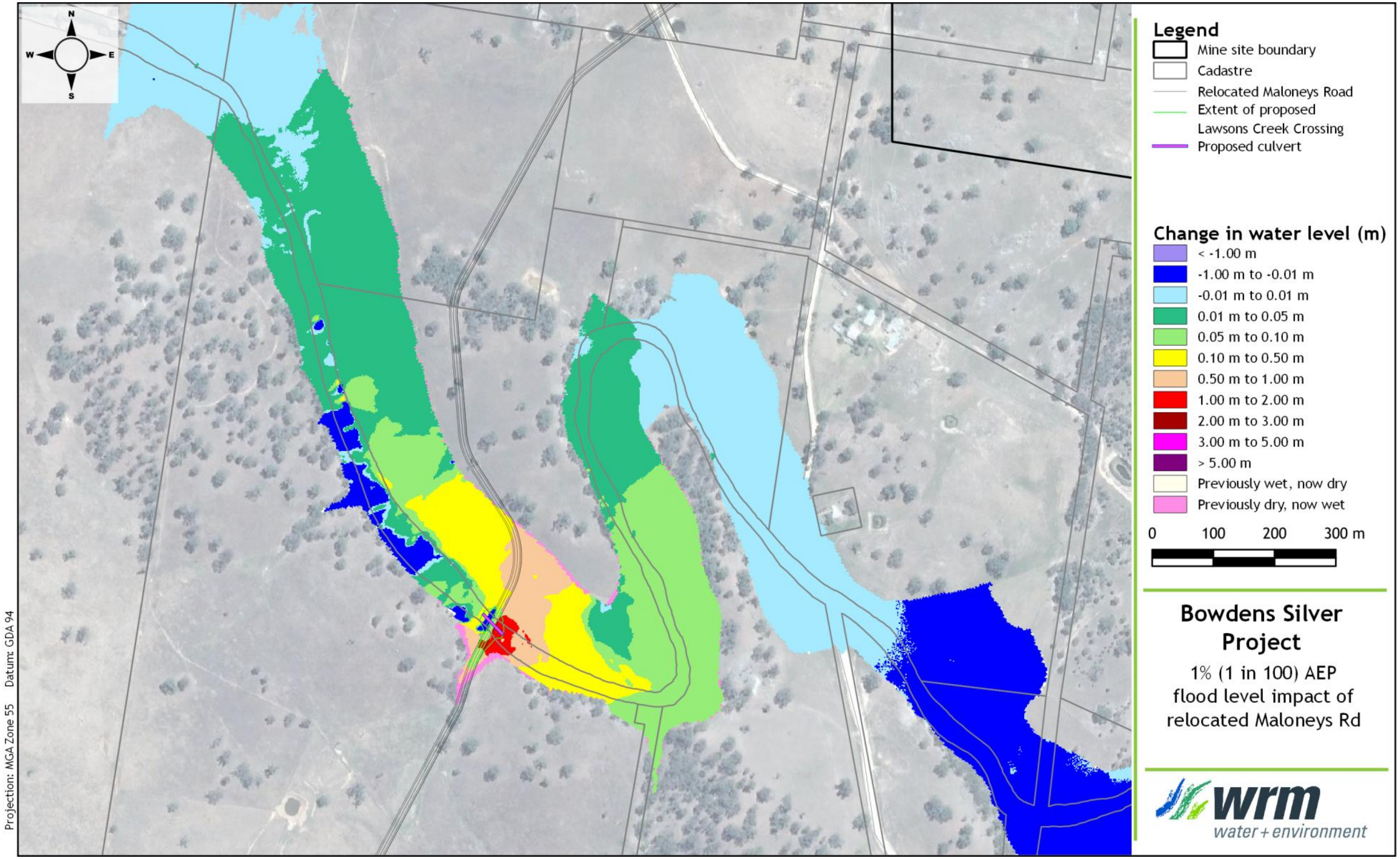


Figure 7.24 – 1% (1 in 100) AEP predicted impacts on peak flood levels along Lawsons Creek in the vicinity of the proposed Lawsons Creek Crossing – Lawsons Creek Crossing Scenario

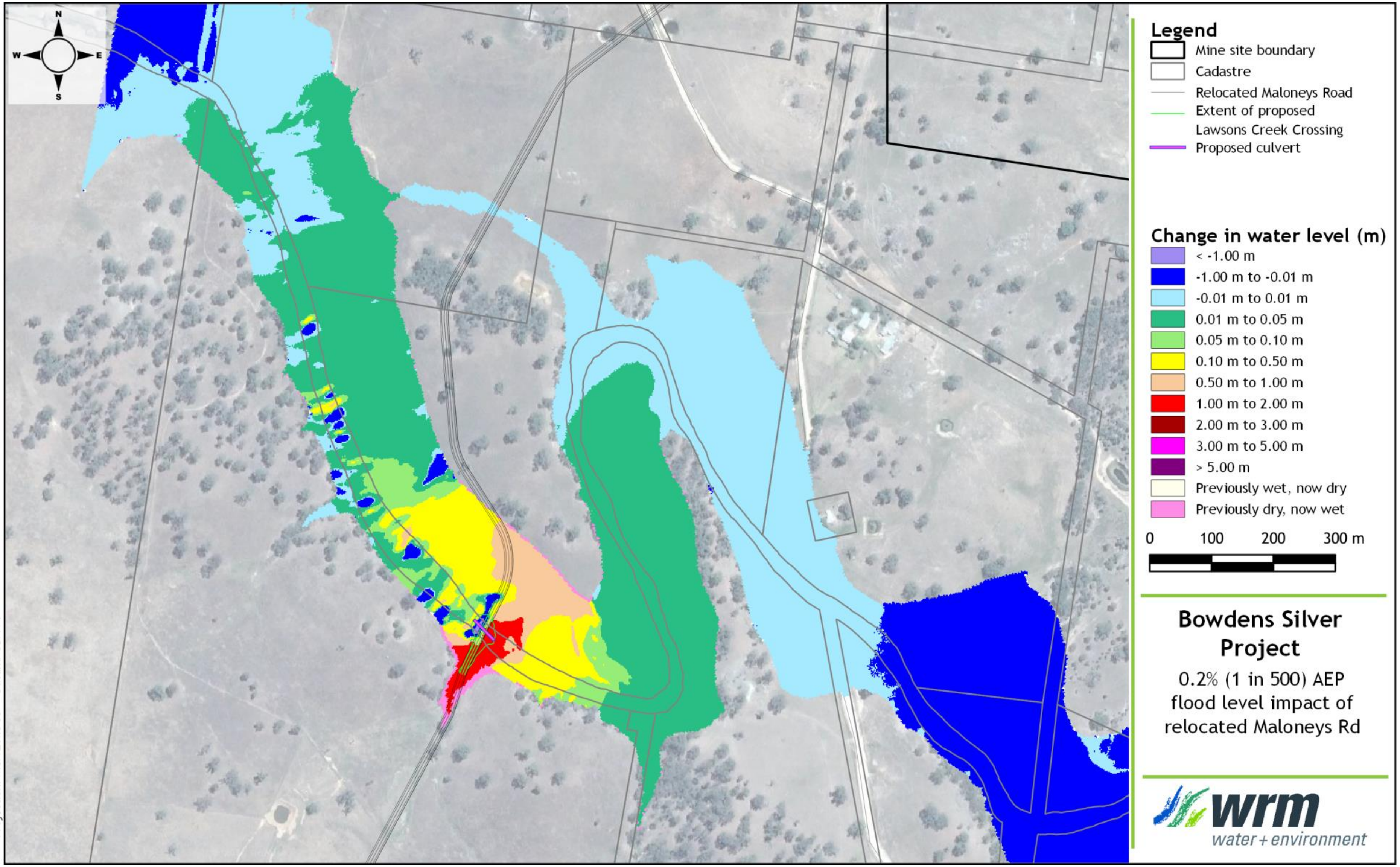


Figure 7.25 - 0.2% (1 in 500) AEP predicted impacts on peak flood levels along Lawsons Creek in the vicinity of the proposed Lawsons Creek Crossing - Lawsons Creek Crossing Scenario

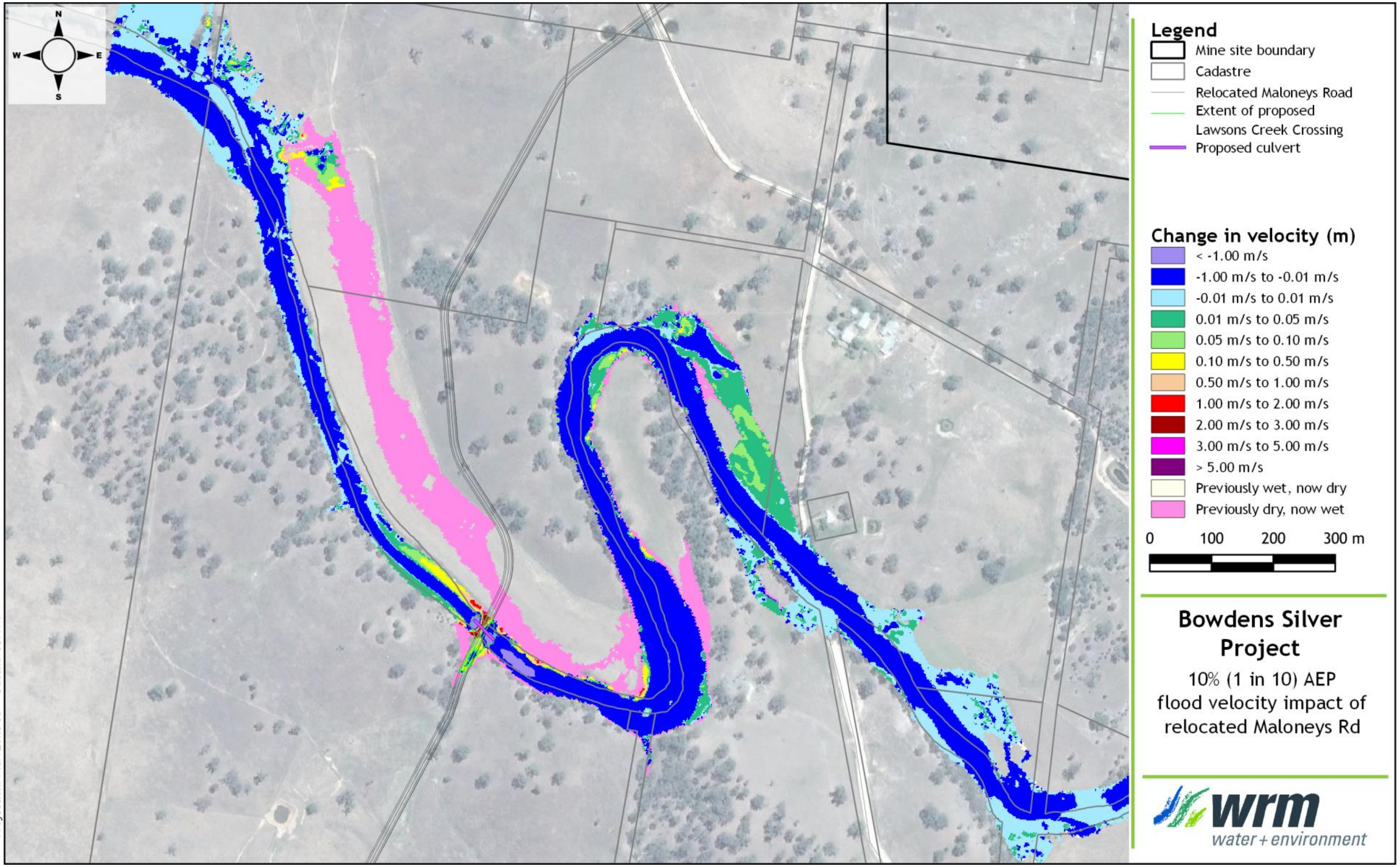


Figure 7.26 – 10% (1 in 10) AEP predicted impacts on peak velocities along Lawsons Creek in the vicinity of the proposed Lawsons Creek Crossing – Lawsons Creek Crossing Scenario

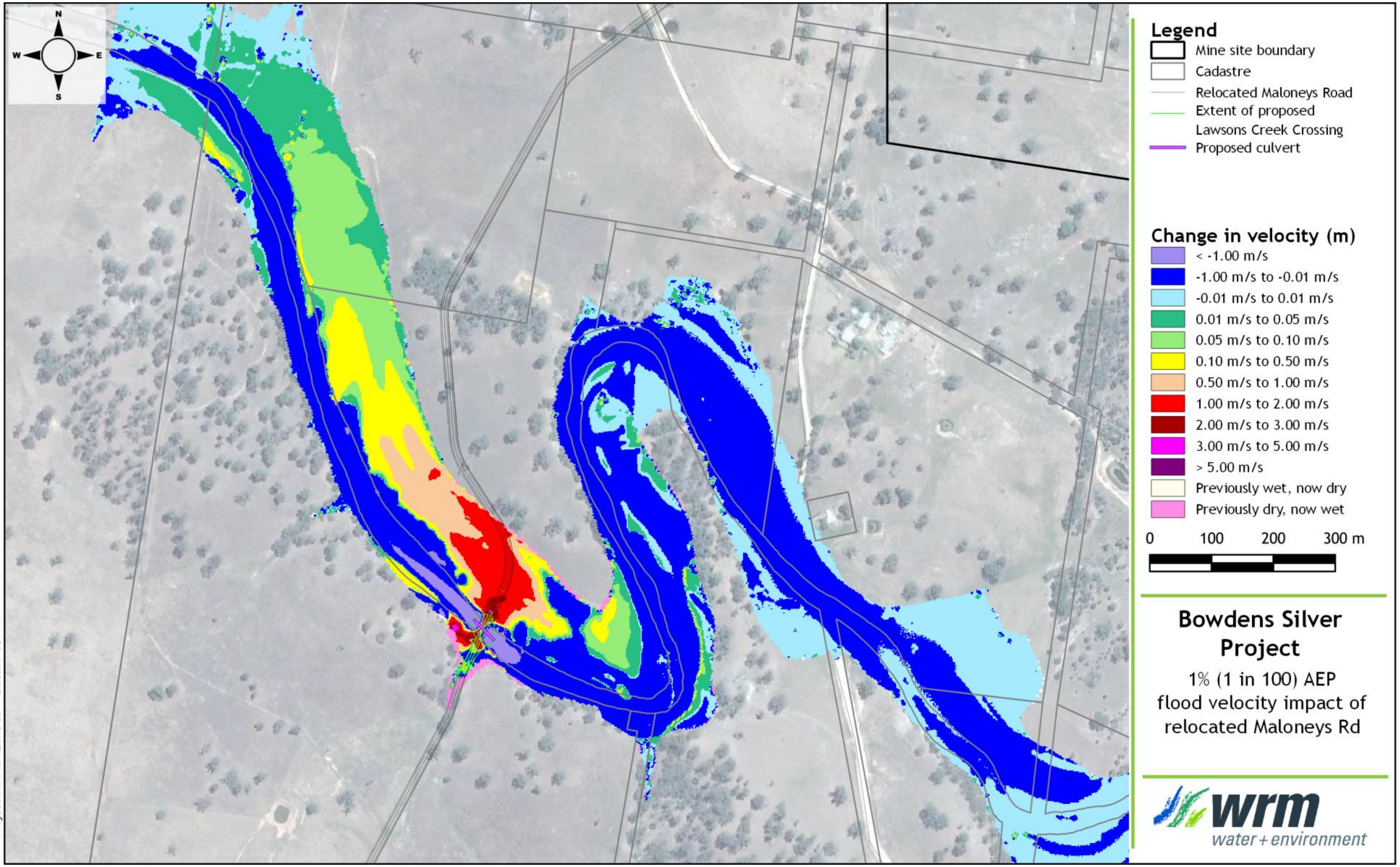


Figure 7.27 – 1% (1 in 100) AEP predicted impacts on peak velocities along Lawsons Creek in the vicinity of the proposed Lawsons Creek Crossing – Lawsons Creek Crossing Scenario

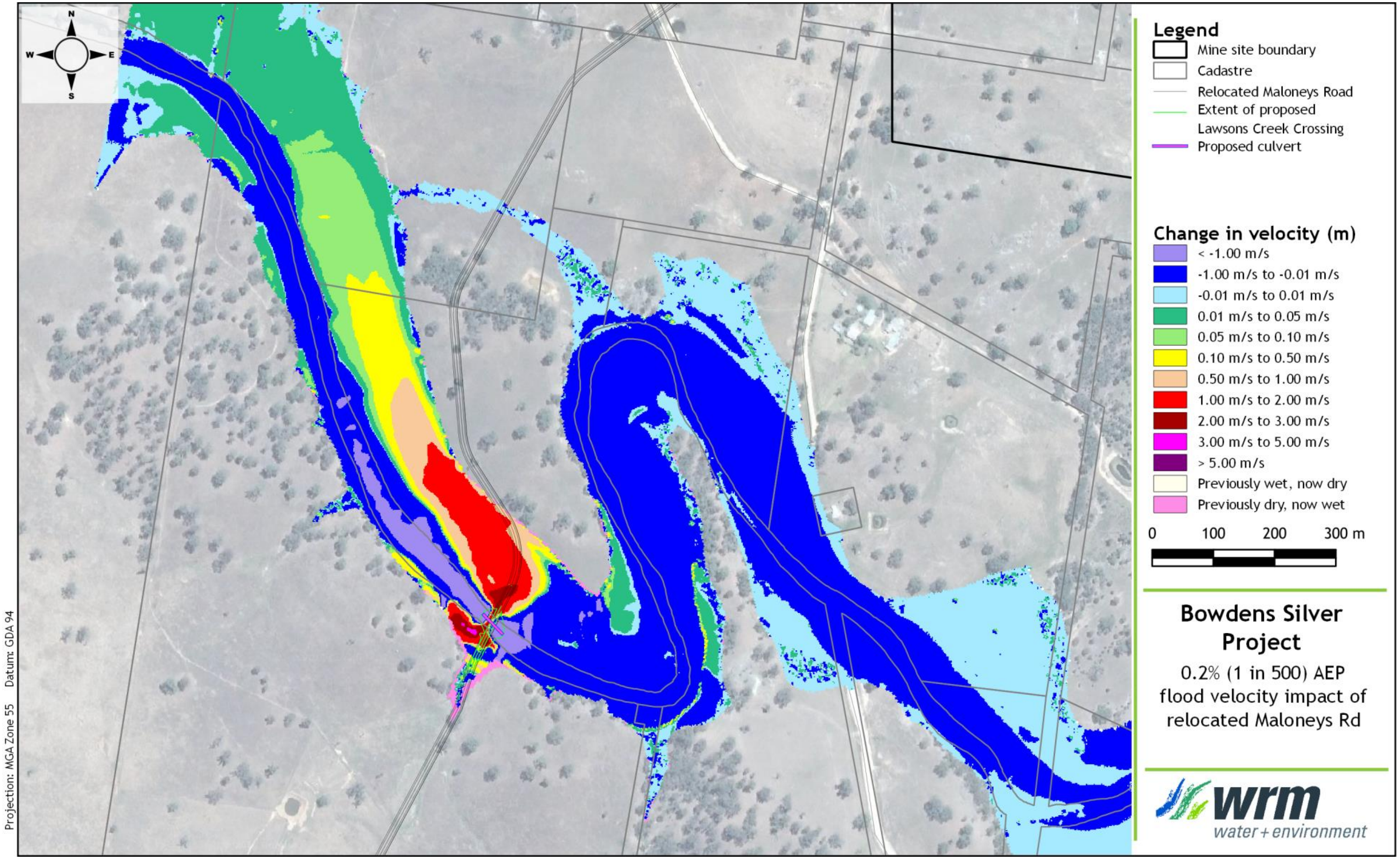


Figure 7.28 – 0.2% (1 in 500) AEP predicted impacts on peak velocities along Lawsons Creek in the vicinity of the proposed Lawsons Creek Crossing – Lawsons Creek Crossing Scenario

8 Summary of findings

8.1 OVERVIEW

An XP-RAFTS hydrologic model was developed for the catchments of Lawsons and Hawkins Creeks and their tributaries. A TUFLOW hydraulic model was also developed for these watercourses to determine existing conditions flood behaviour in the vicinity of the Project disturbance area.

8.2 HYDROLOGIC MODELLING

The XP-RAFTS model was validated recorded water level data at the Powells Road (Stn No. 421195) and Bingmans Crossing (Stn No. 421194) recording stations for one event in July 2016 and two events in September 2016. Rating (stage-discharge) curves for each of these recording stations were developed using a combination of theoretical rating curves and hydraulic modelling results. The rating curves were used to convert recorded water level data into discharges for model validation.

For the September 2016 (1st flow event), modelled peak discharges were within 15% to 20% of the recorded peak discharge (with a continuing loss rate of 4 mm/h). Very high continuing loss rates were required to achieve a good match to the peak discharges recorded during the July 2016 event and the September 2016 (2nd flow event), which may be partly caused the site rainfall recordings overestimating the catchment rainfall during these events. However, the results show that the model is able to reproduce the timing and shape of the hydrographs reasonably well.

The XP-RAFTS model was used to estimate design discharges for the 10% (1 in 10), 5% (1 in 20), 2% (1 in 50), 1% (1 in 100), 0.5% (1 in 200) and 0.2% (1 in 500) AEP events as well as the PMP design event. Design discharges were estimated using the AR&R 2016 event ensemble methodology. The resulting peak discharges were validated against peak discharges estimated using the RFFE technique.

8.3 HYDRAULIC MODELLING

The TUFLOW hydraulic model was developed for the study area with a grid cell size of three metres. The discharges estimated using the XP-RAFTS runoff-routing model were adopted as inflows to the TUFLOW hydraulic model.

Key points with regards to predicted peak flood levels and depths across the study area are summarised below:

- The Project disturbance area is located outside of the predicted Lawsons Creek flood extent for all events up to the probable maximum precipitation (PMP) design event.
- The area along the southeastern Mine Site boundary is affected by flooding from Hawkins Creek. However, the proposed open cut pits, WRE and leachate management dam are located outside of the predicted flood extent for Hawkins Creek for all design events.
- Flooding along the Hawkins Creek and Lawsons Creek tributaries within the Mine Site is characterised by shallow overland flows. Flows in these tributaries are generally confined within narrow flood flow paths, with no breakouts occurring except near the confluences of these tributaries with Hawkins and Lawsons Creeks. Due to the narrow flood flow paths, the difference in predicted flood extents along these tributaries between the 1% Annual Exceedance Probability (AEP) and PMP design events is not significant.

- Predicted peak flood depths along the overbank areas of the Hawkins and Lawsons Creek tributaries are generally below one metre for events up to and including 0.2% (1 in 500) AEP. Peak flood depths of up to 1.5 m for the PMP design event are predicted in some sections along these tributaries.

Key points with regards to predicted peak velocities across the study area are summarised below:

- Flows in the Lawsons Creek and Hawkins Creek tributaries are generally confined within narrow flood flow paths with relatively steep ground slopes. This results in relatively high predicted peak flood velocities of up to 2.5 m/s along the channel and overbank areas of these tributaries for events up to and including 0.2% AEP. The proposed mine infrastructure would increase flood velocities in localised areas, and mitigation works would be required to manage erosion risks along the lower perimeter embankment of the WRE during operations and after mine closure.
- Existing peak flood velocities in Hawkins Creek for events up to and including 0.2% AEP are generally less than 3 m/s, with peak velocities greater than 4 m/s predicted in some sections. The Project results in some redistribution of tributary inflows to Hawkins Creek, and as a result there would be a minor increase (less than 0.1 m/s) in flood velocities immediately adjacent to the Mine Site.
- Existing peak flood velocities in Lawsons Creek are relatively high for all modelled events. For events up to and including 0.2% AEP, peak flood velocities greater than 4 m/s are predicted in many sections along the Lawsons Creek channel and floodplain. The proposed mine infrastructure would have minimal impact on Lawsons Creek flood velocities.

In summary, the works associated with the proposed WRE would result in localised minor flood level increases. The more significant flood level impacts are constrained to within the lease, and would not result in significant impacts to other properties, assets or infrastructure. The proposed WRE would also locally increase flood velocities in its immediate vicinity. Local scour protection measures would need to be developed during detailed design to mitigate the potential erosion impacts in this area. Any expected increases in flood velocities in Hawkins Creek and Lawsons Creek are negligible and would not adversely impact offsite property or infrastructure.

Key points with regards to flood conditions at the relocated Maloneys Road (Pyangle Road) crossing of Lawsons Creek are summarised below. The results indicate that:

- The upstream impacts of the proposed crossing decrease with increasing flood magnitude.
- The proposed road crossing would be overtopped during a 10% (1 in 10) AEP flood event. Peak flood depths over the road are up to 1.2 m, while peak flood velocities over the road are up to 3 m/s. Therefore, the proposed road crossing would be non trafficable by light or heavy vehicles during a 10% AEP event.
- Due to the predicted increase in peak flood levels upstream of the crossing, flows in Lawsons Creek would overtop the northern creek bank immediately upstream of the crossing. In the 10% AEP flood, these overflows would drain to the northwest parallel to the Lawsons Creek before re-joining Lawsons Creek about 680 m downstream of the proposed crossing. In larger flows, a greater proportion of flow would be directed along the northeast floodplain, resulting in increased floodplain velocities.
- The predicted increases in peak flood levels and flood extents for the 10% AEP event would not affect any existing dwellings. It is noted that Bowdens Silver either owns or holds the option to purchase all properties that are predicted to be affected by an increase in flood levels.

- The road crossing would be designed to manage the risk of scour induced by increased velocities, for example through the use of dumped rock or other erosion protection measures.

9 References

Ball et al, 2019	Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I (Editors), 2019, *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia
BMT, 2019	BMT Pty Ltd 2019, *TUFLOW User Manual – GIS Based 1D/2D Hydrodynamic Modelling,* Brisbane QLD
BoM, 2003	Commonwealth Bureau of Meteorology, June 2003, *Guidebook to the Estimation of Probable Maximum Precipitation: Generalised Short-Duration Method*, Hydrometeorological Advisory Service
BoM, 2006	Commonwealth Bureau of Meteorology, October 2006, *Guidebook to the Estimation of Probable Maximum Precipitation: Generalised Southeast Australia Method*, Hydrometeorological Advisory Service
BoM, 2016	Commonwealth Bureau of Meteorology, 2016, *Design rainfalls for Australia: data, methods and analyses*, Melbourne VIC.
Chow, 1959	V.T Chow, 1959, *Open Channel Hydraulics*, McGraw-Hill Book Company, NY
Jordan et al, 2005	Jordan P, Nathan R, Mittiga L and Taylor B, 2005, *Growth Curves and Temporal Patterns for Application to Short Duration Extreme Events*, Aust J Water Resour Volume 9(1), pp.69-80.
Innovyze, 2018	Innovyze Pty Ltd, XP-RAFTS User Manual, 2018

Appendix A - XP-RAFTS subcatchment parameters

Table A.1 – Adopted XP-RAFTS subcatchment parameters

Subcatchment ID	Area (km^2)	Percentage impervious (%)	Catchment slope (%)	Catchment PERN 'n'
BG001	0.10	0	10.9	0.050
BG002	0.77	0	2.6	0.040
BG003	0.27	0	11.2	0.050
BG004	0.04	0	21.2	0.050
BG005	0.20	0	5.6	0.040
BG006	0.07	0	16.8	0.040
BG007	0.89	0	3.9	0.040
HA001	4.09	0	2.4	0.035
HA002	4.15	0	1.9	0.035
HA003	4.05	0	2.3	0.035
HA004	4.73	0	4.6	0.050
HA005	3.76	0	3.3	0.050
HA006	1.95	0	5.5	0.040
HA007	3.24	0	2.8	0.035
HA008	2.14	0	1.8	0.035
HC001	3.13	0	4.0	0.050
HC002	3.39	0	4.5	0.050
HC003	3.11	0	2.9	0.050
HC004	4.10	0	3.2	0.050
HC005	3.76	0	3.0	0.050
HC006	1.61	0	5.2	0.050
HC007	4.89	0	3.2	0.050
HC008	4.55	0	3.5	0.050
HC009	4.70	0	1.5	0.035
HC010	5.87	0	7.0	0.050
HC011	3.80	0	4.8	0.050
HC012	3.07	0	0.9	0.035
HC013	4.08	0	5.0	0.050
HC014	0.78	0	2.0	0.035
HC016	0.42	0	5.9	0.050
HC017	0.62	0	1.6	0.035
HC018	0.43	0	4.0	0.035
HC019	0.67	0	2.8	0.035
HC020	0.22	0	6.2	0.040
HC021	0.26	0	6.1	0.040
LC001	6.92	0	2.3	0.050
LC002	5.35	0	1.9	0.050
LC003	3.36	0	3.2	0.050
LC004	4.63	0	2.5	0.050
LC005	6.55	0	3.5	0.040
LC006	7.38	0	2.1	0.040
LC007	6.80	0	1.3	0.035
LC008	6.19	0	3.5	0.035
LC009	5.62	0	2.2	0.035
LC010	5.61	0	1.7	0.035
LC011	9.12	0	2.8	0.050

Subcatchment ID	Area (km^2)	Percentage impervious (%)	Catchment slope (%)	Catchment PERN 'n'
LC012	6.65	0	3.2	0.040
LC013	4.42	0	2.4	0.040
LC014	6.01	0	2.4	0.040
LC015	6.12	0	3.1	0.050
LC016	4.42	0	2.4	0.040
LC017	8.51	0	3.2	0.050
LC018	4.11	0	4.6	0.040
LC019	5.54	0	2.9	0.035
LC020	4.22	0	3.7	0.050
LC021	3.83	0	3.8	0.035
LC022	3.19	0	1.9	0.035
LC023	4.68	0	2.7	0.035
LC024	3.97	0	1.4	0.035
LC025	5.43	0	2.4	0.035
LC026	3.70	0	4.1	0.035
LC027	4.61	0	2.5	0.035
LC028	2.69	0	2.4	0.035
LC029	4.88	0	1.4	0.035
LC030	2.49	0	0.8	0.035
LC031	3.39	0	2.9	0.035
LC032	2.76	0	2.3	0.035
LC033	2.77	0	4.1	0.035
LC034	1.90	0	4.7	0.035
LC035	2.18	0	0.7	0.035
LC036	3.45	0	1.9	0.035
LC037	1.56	0	4.7	0.040
LC038	1.14	0	3.3	0.035
LC039	0.98	0	8.3	0.040
LC040	1.62	0	3.4	0.035
LC041	1.87	0	1.4	0.035
LC042	1.16	0	4.1	0.035
LC043	0.41	0	7.7	0.040
LC044	0.64	0	3.9	0.040
PC001	1.06	0	8.6	0.050
PC002	1.55	0	4.7	0.050
PC003	0.69	0	7.3	0.050
PC004	0.67	0	4.1	0.040
PC005	1.21	0	3.4	0.035

Appendix B - Design discharges from AR&R 2016 event ensemble (1 in 100 AEP)

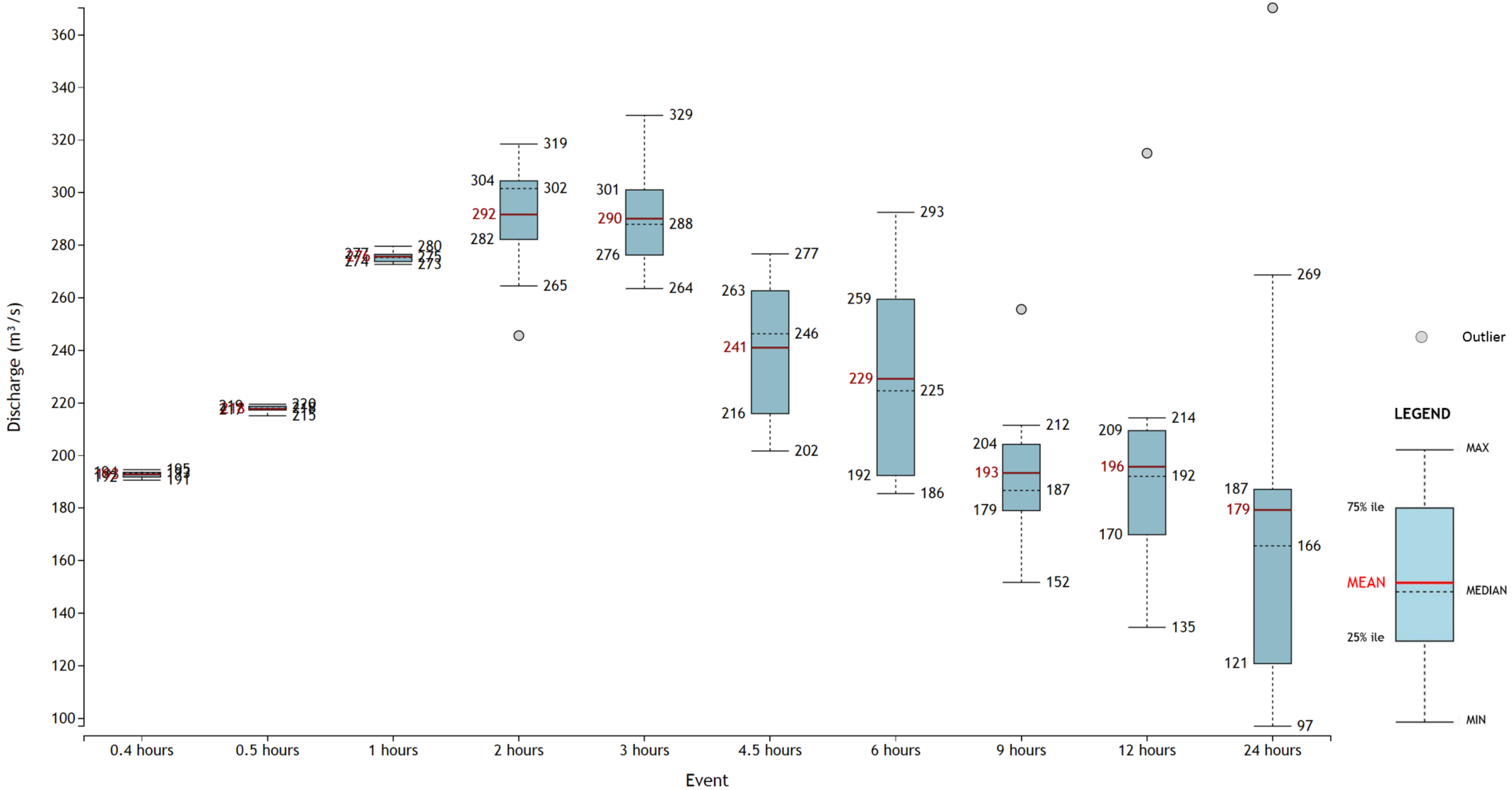


Figure B.1 – Ensemble of 1% (1 in 100) AEP predicted peak discharges in Hawkins Creek at Powells Road

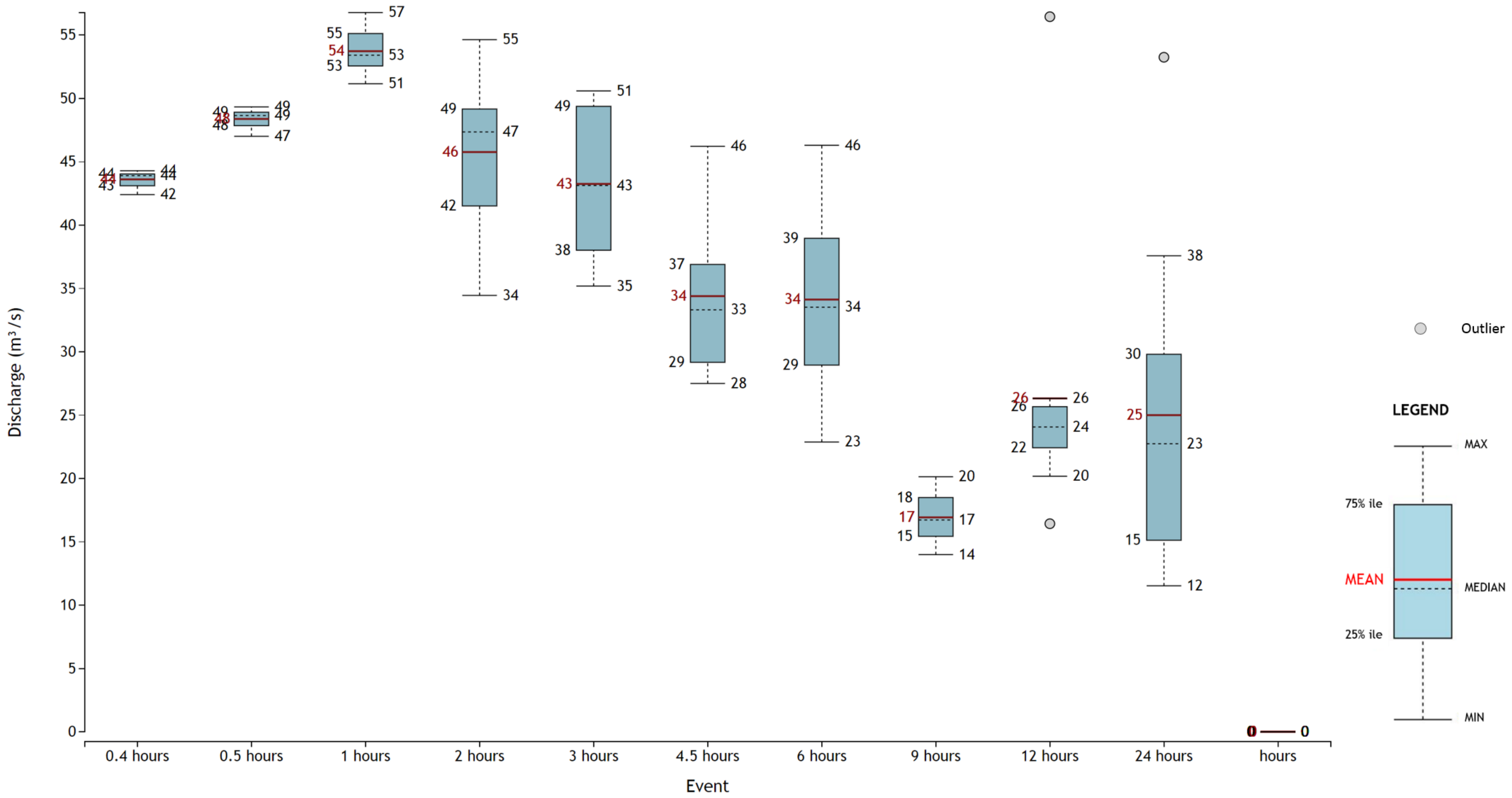


Figure B.2 – Ensemble of 1% (1 in 100) AEP predicted peak discharges in Price Creek upstream of Hawkins Creek confluence

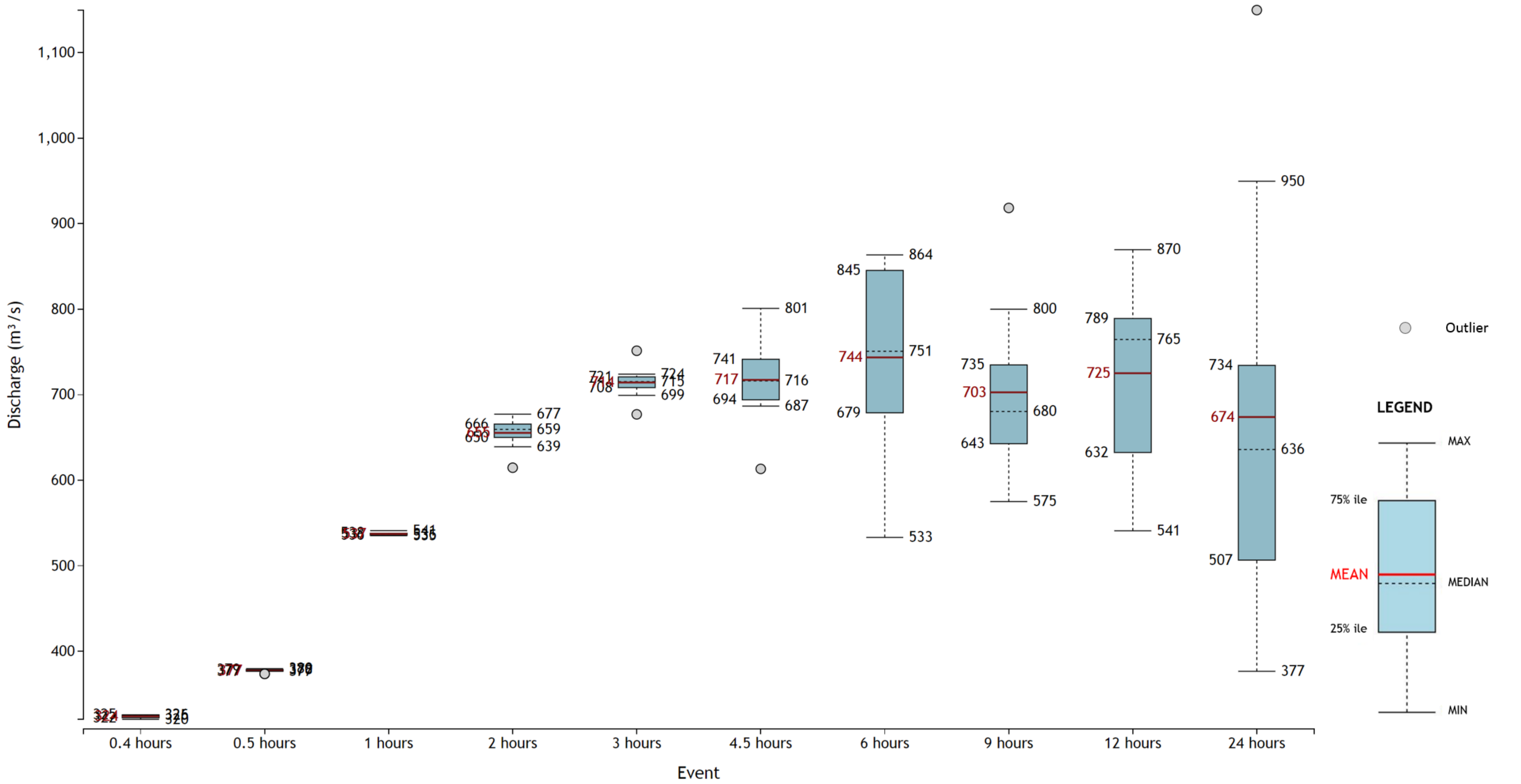
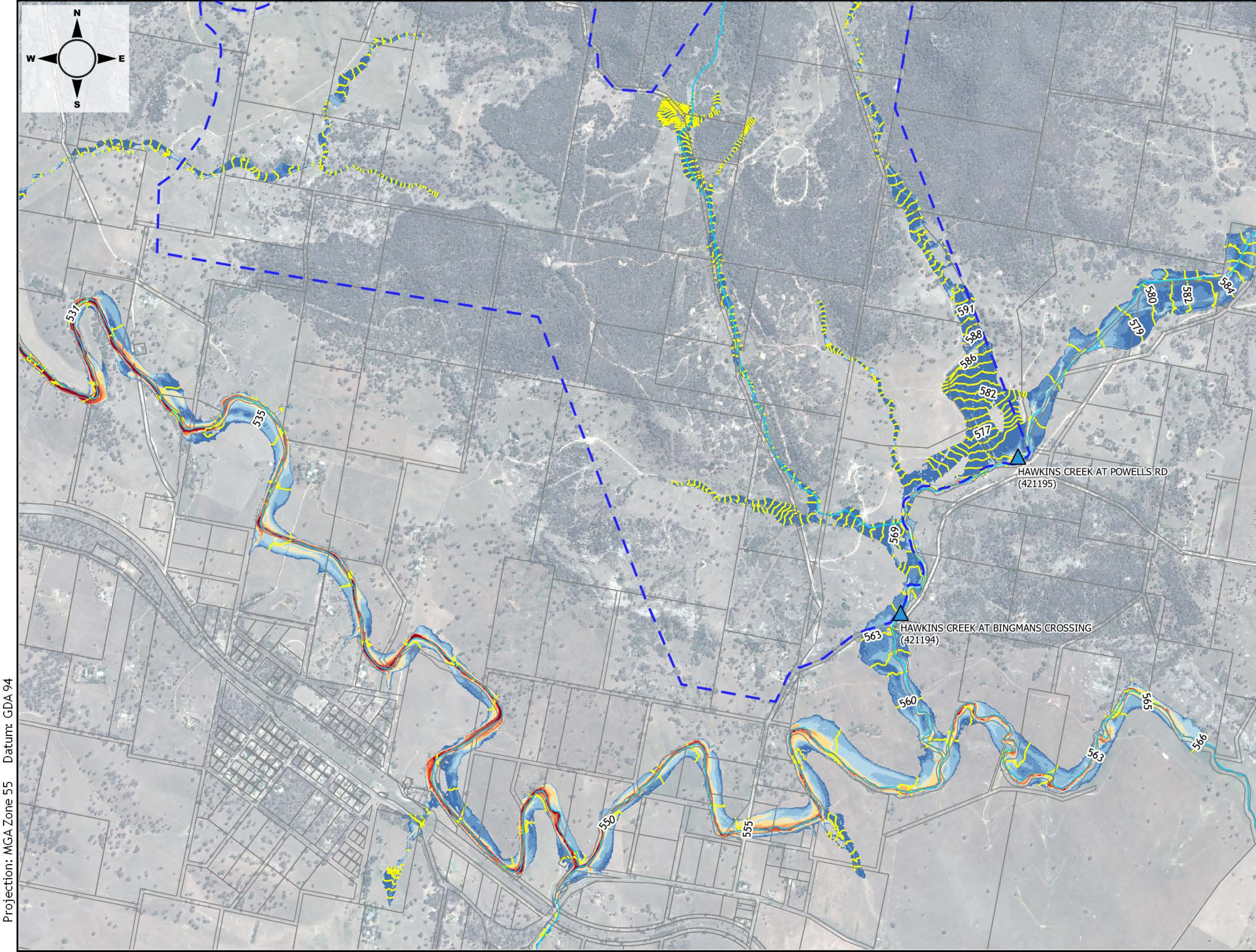


Figure B.3 – Ensemble of 1% (1 in 100) AEP predicted peak discharges in Lawsons Creek at the XP-RAFTS model outlet

Appendix C - Flood maps - Base case



Legend

- Major watercourse
- Mine Site boundary
- Cadastre
- Streamflow gauge
- Water level contour (1m)

Depth

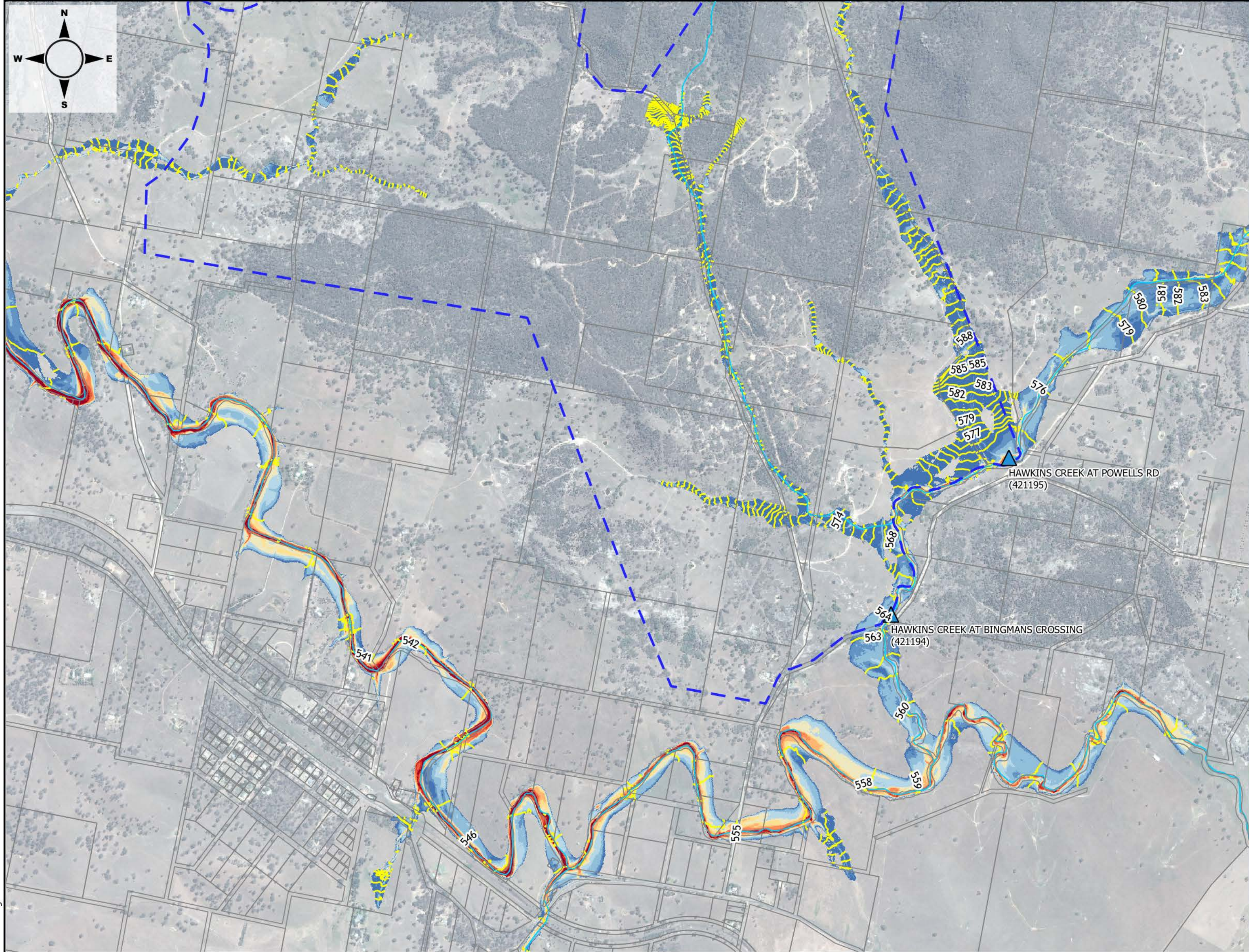
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

0 0.25 0.5 0.75 1 km

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 10% AEP

wrm water+environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Major watercourse
- Mine Site boundary
- Cadastre
- Streamflow gauge
- Water level contour (1m)

Depth

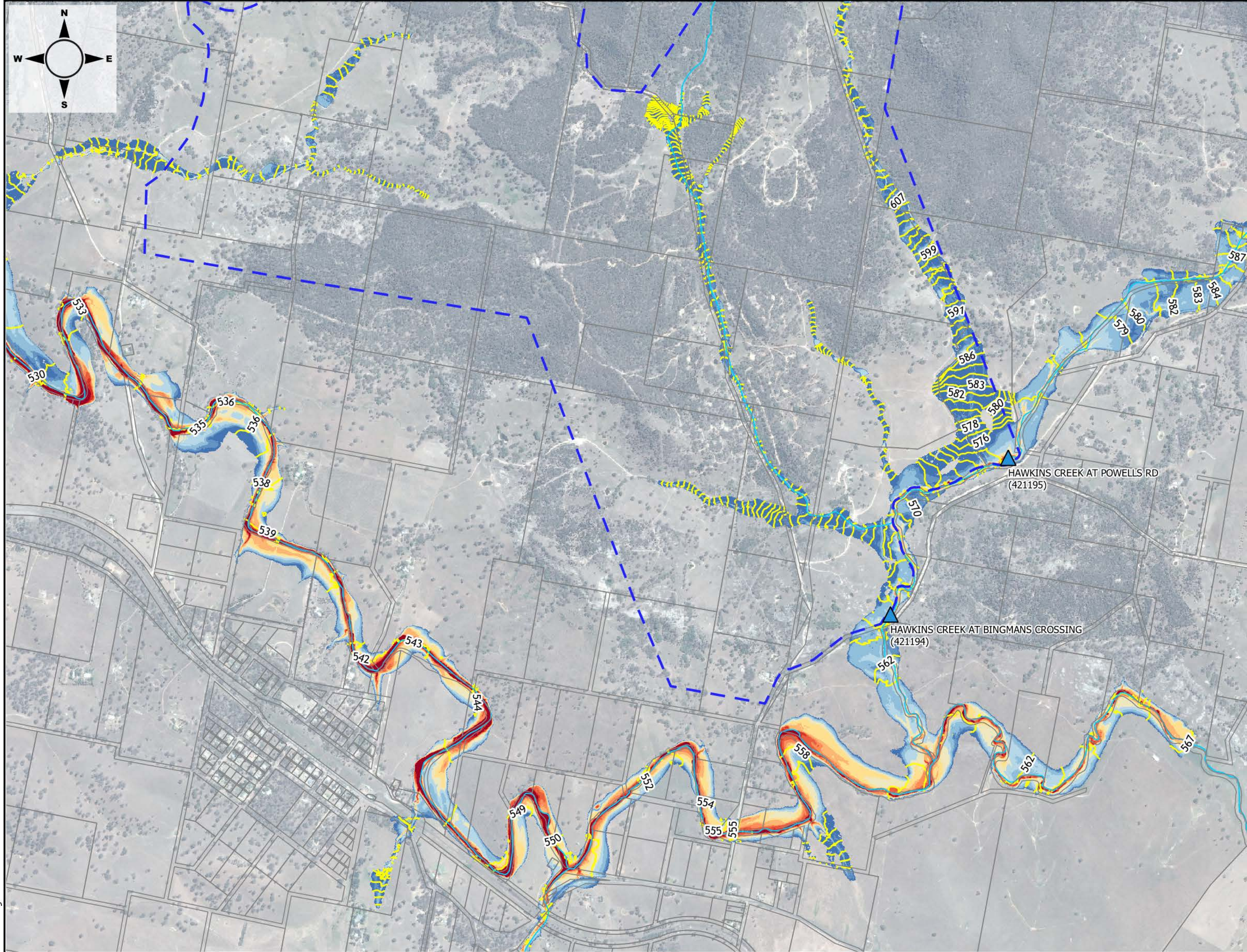
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

0 0.25 0.5 0.75 1 km

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 5% AEP

wrm water + environment



Legend

- Major watercourse
- Mine Site boundary
- Cadastre
- Streamflow gauge
- Water level contour (1m)

Depth

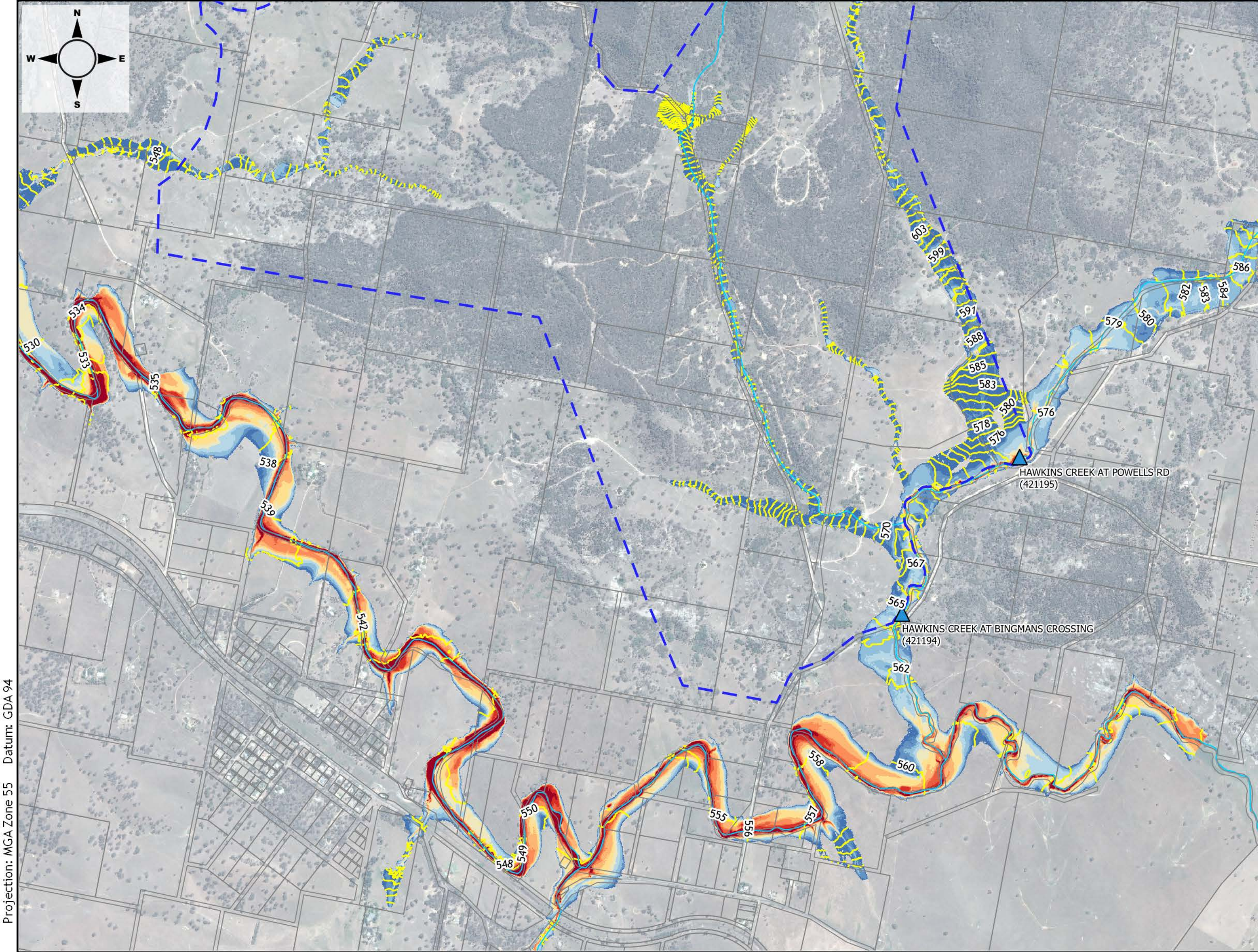
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

0 0.25 0.5 0.75 1 km

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 2% AEP

wrm water + environment



Legend

- Major watercourse
- Mine Site boundary
- Cadastre
- Streamflow gauge
- Water level contour (1m)

Depth

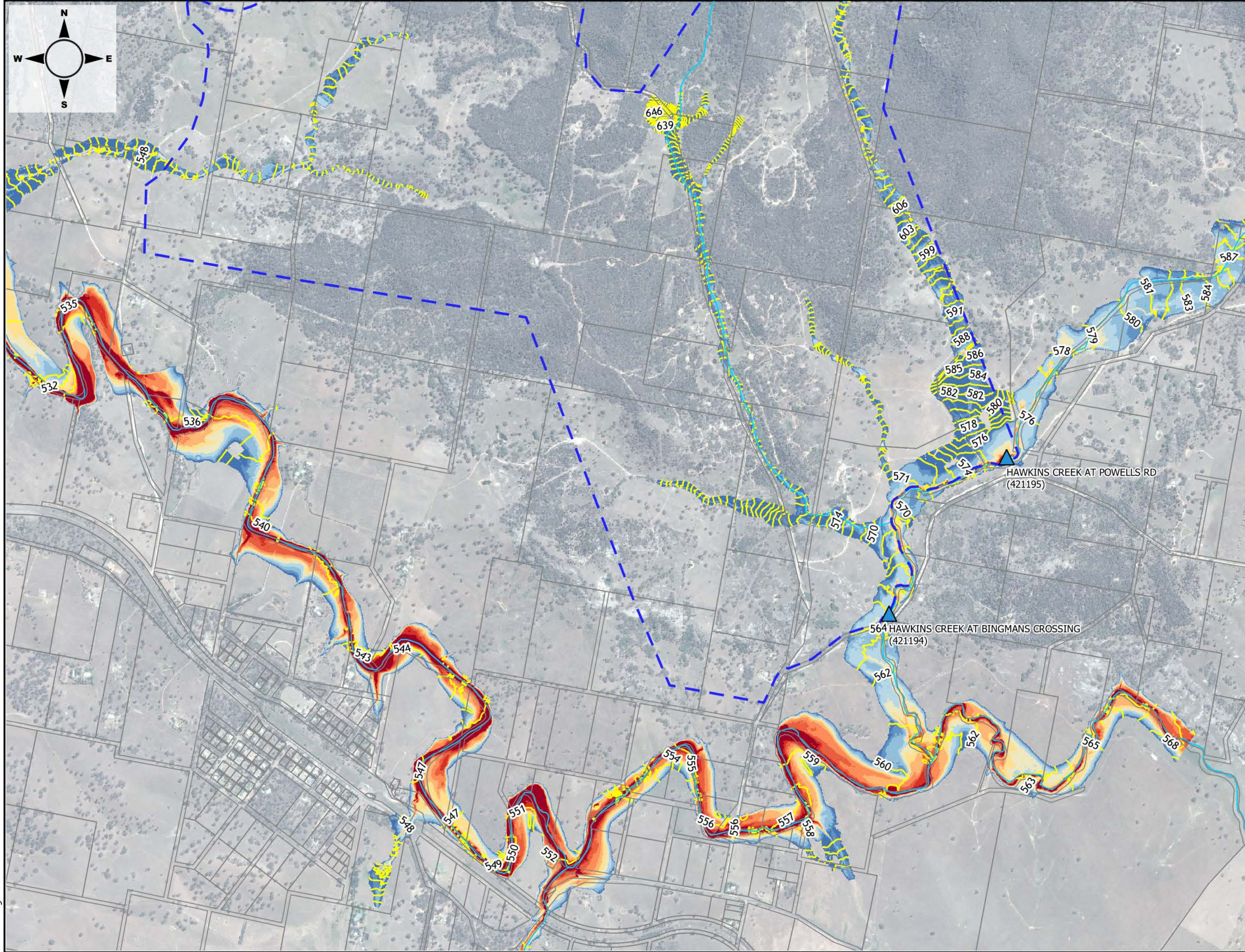
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

0 0.25 0.5 0.75 1 km

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 1% AEP

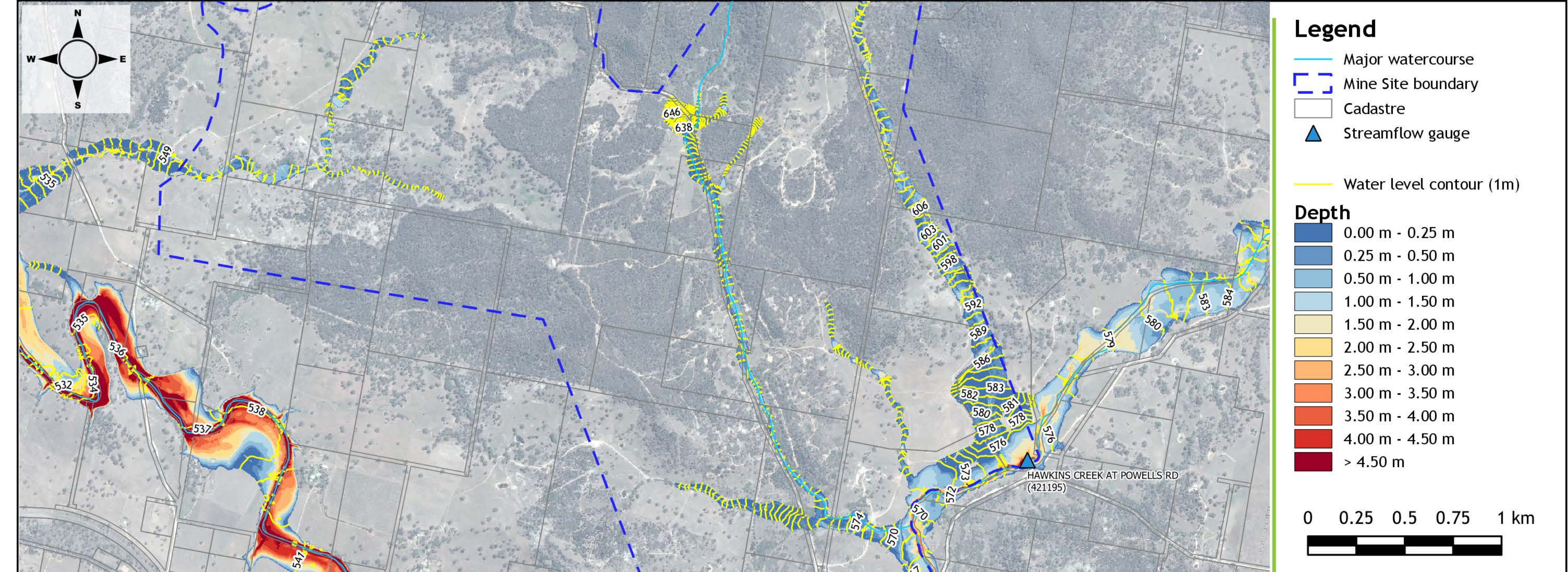
wrm water + environment



Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 0.5% AEP

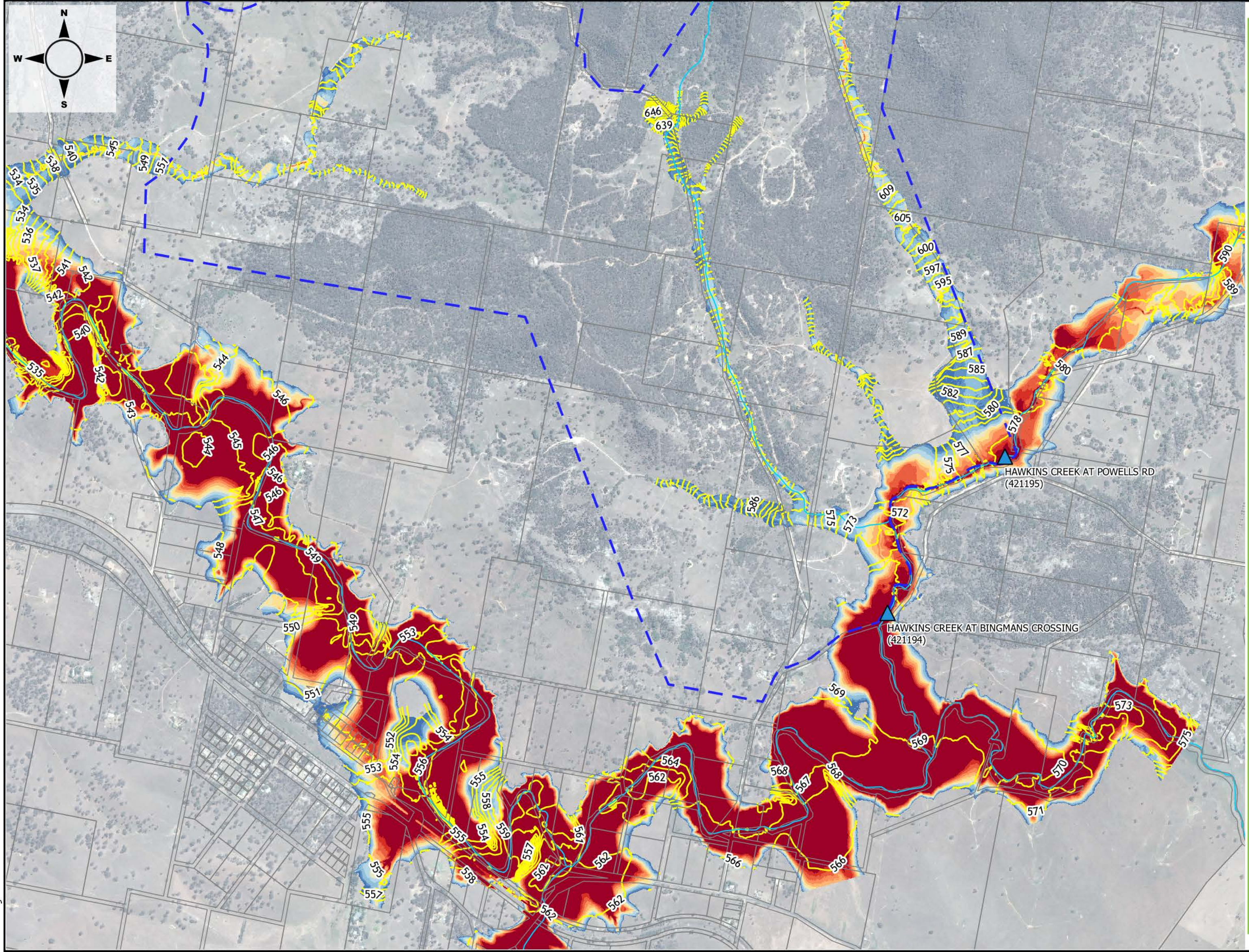
wrm water + environment



Bowdens Silver Project

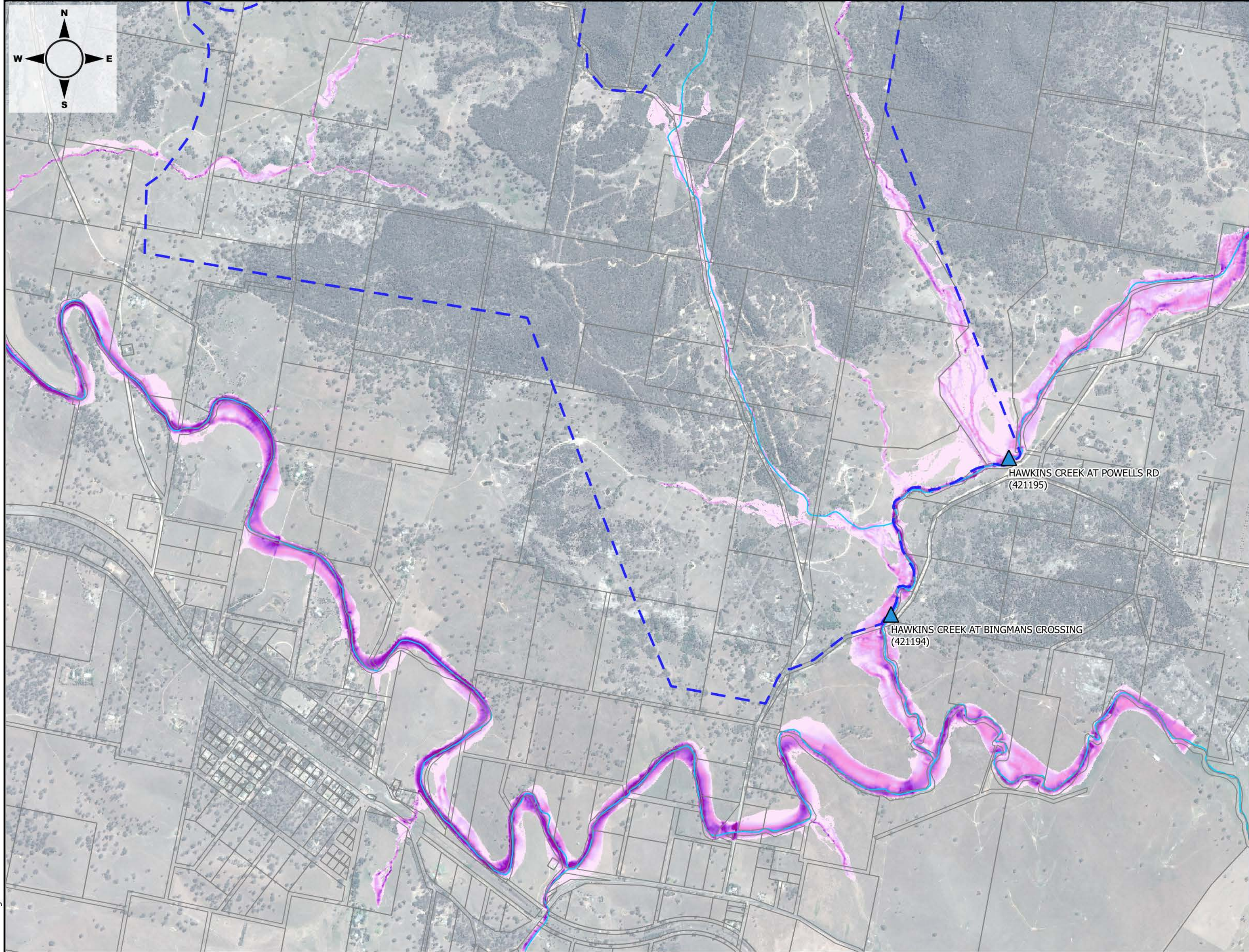
Predicted Flood Extents & Depths (Existing Condition), 0.2% AEP

wrm water + environment



Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), PMF



Legend

- Major watercourse
- Mine Site boundary
- Cadastre
- Streamflow gauge

Velocity

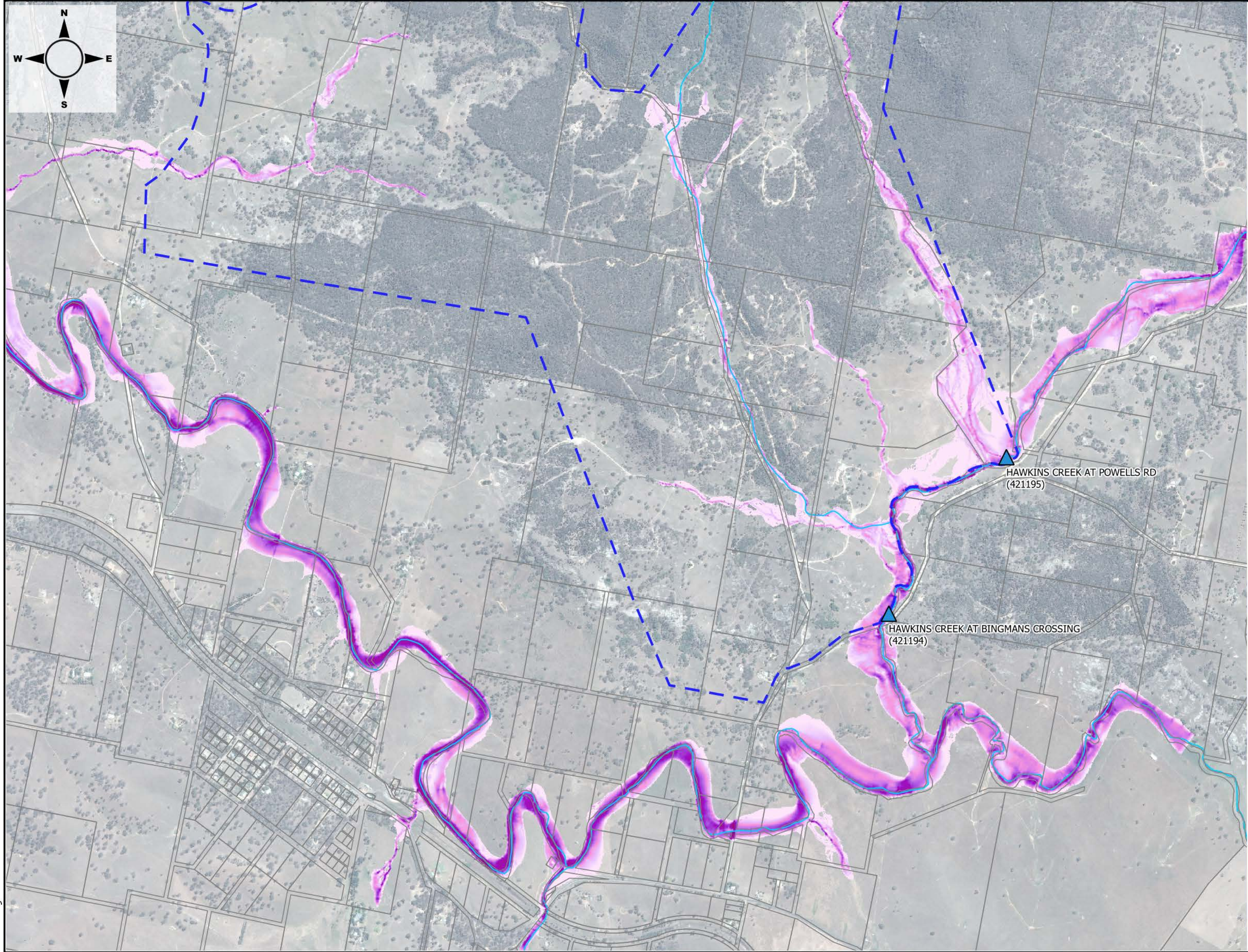
- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 10% AEP

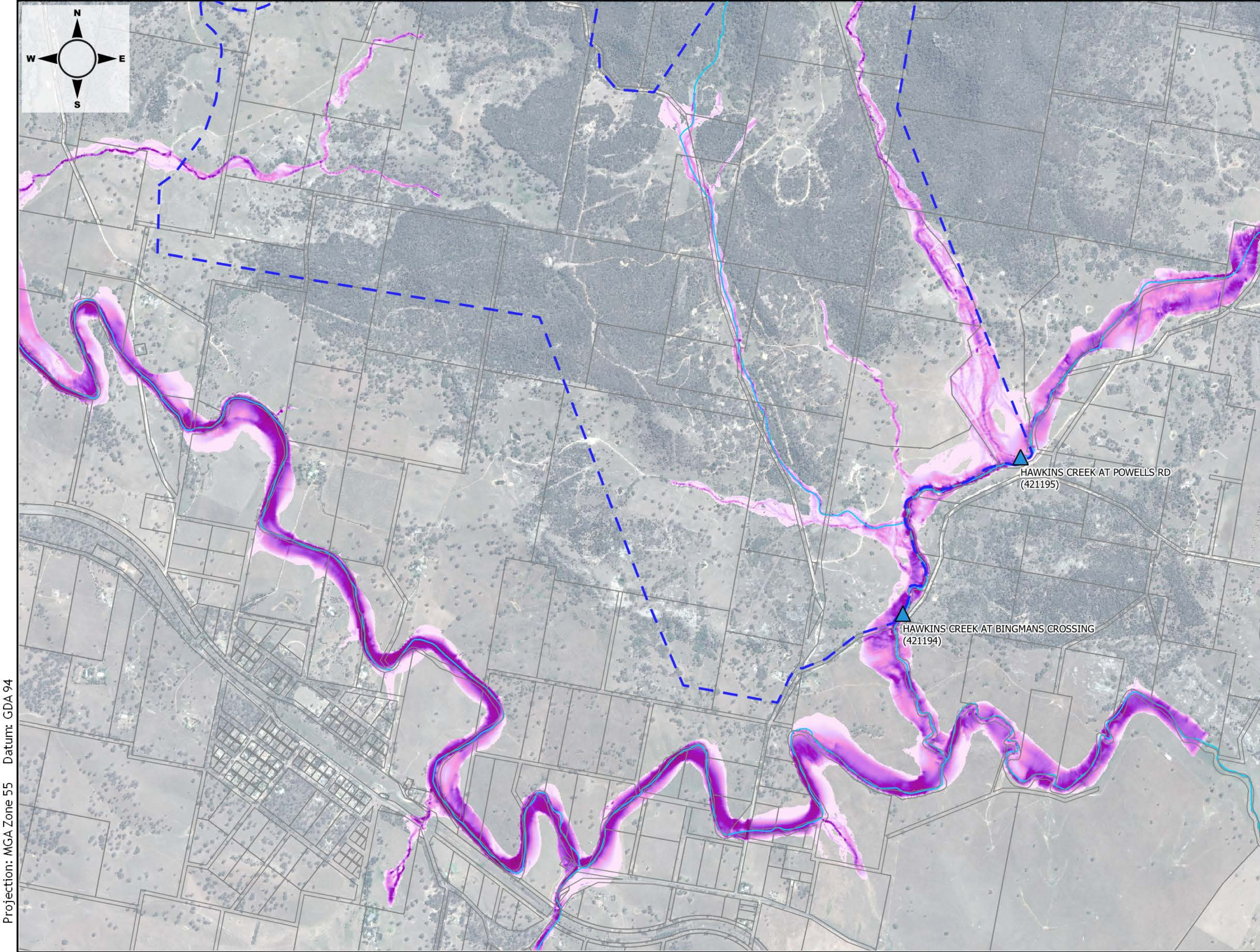
wrm water + environment



Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 5% AEP

wrm water + environment



Legend

- Major watercourse
- Mine Site boundary
- Cadastre
- Streamflow gauge

Velocity

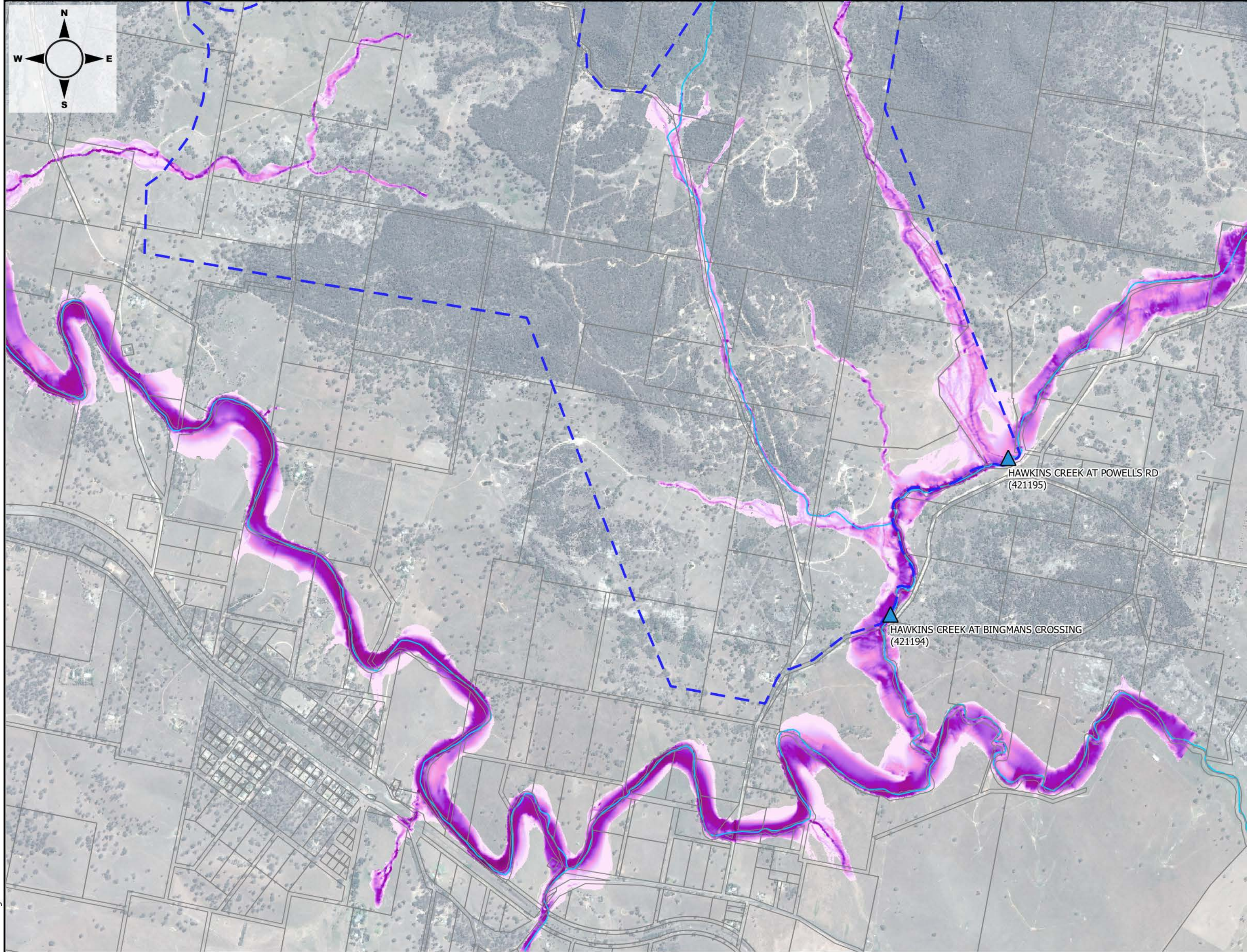
- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 2% AEP

wrm water + environment



Legend

- Major watercourse
- Mine Site boundary
- Cadastre
- Streamflow gauge

Velocity

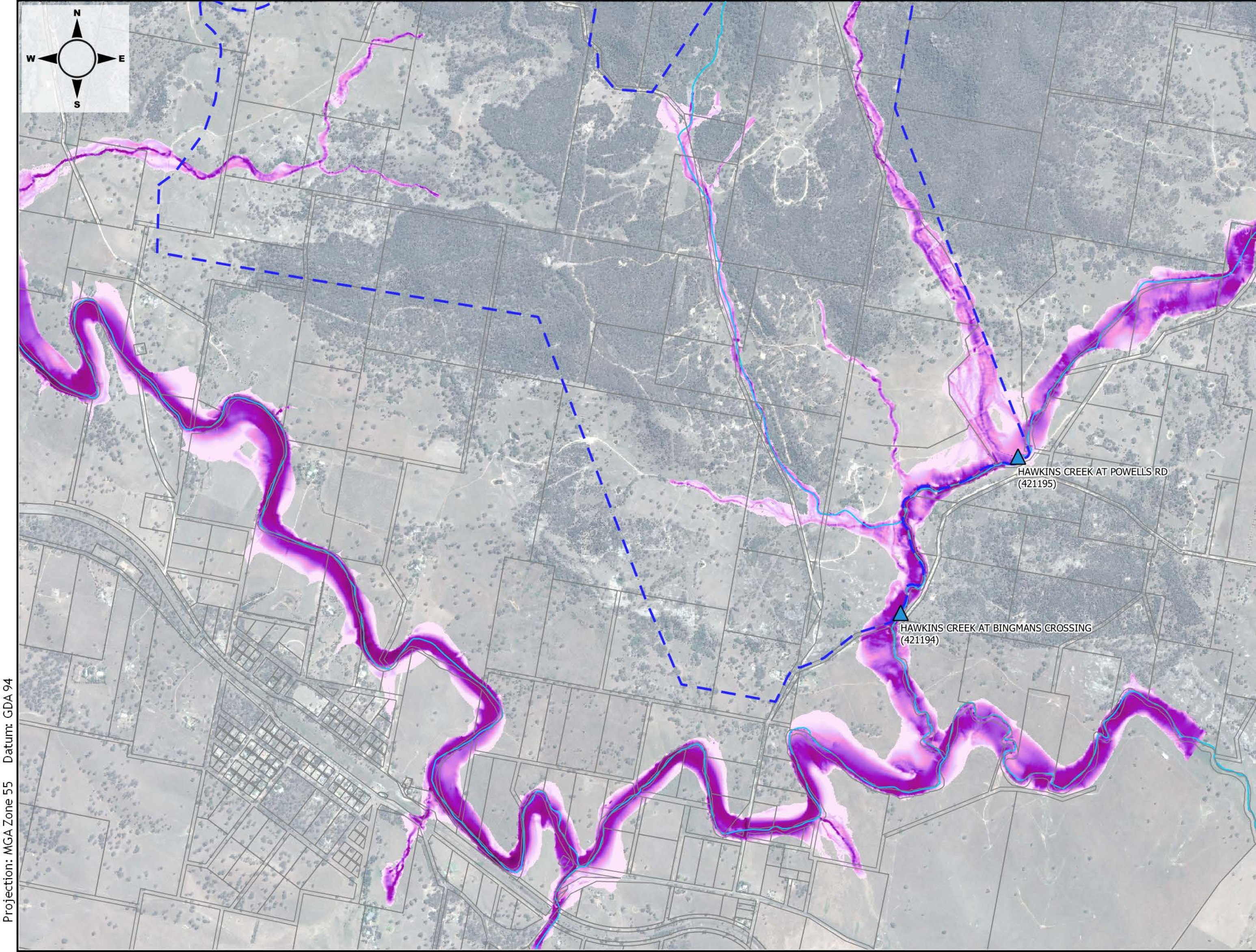
- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 1% AEP

wrm water + environment



Legend

- Major watercourse
- Mine Site boundary
- Cadastre
- Streamflow gauge

Velocity

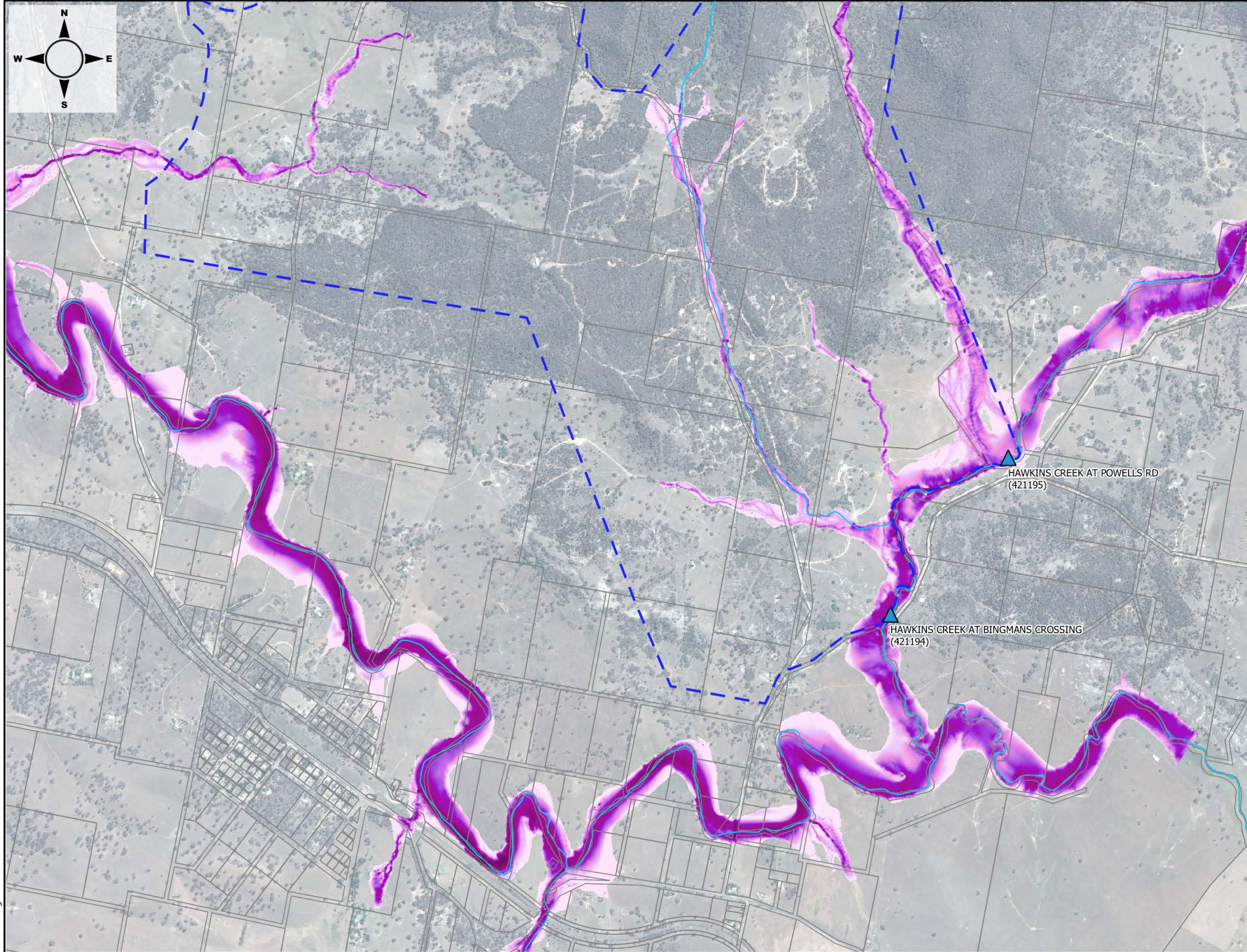
- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 0.5% AEP

wrm water + environment



Legend

- Major watercourse
- Mine Site boundary
- Cadastre
- Streamflow gauge

Velocity

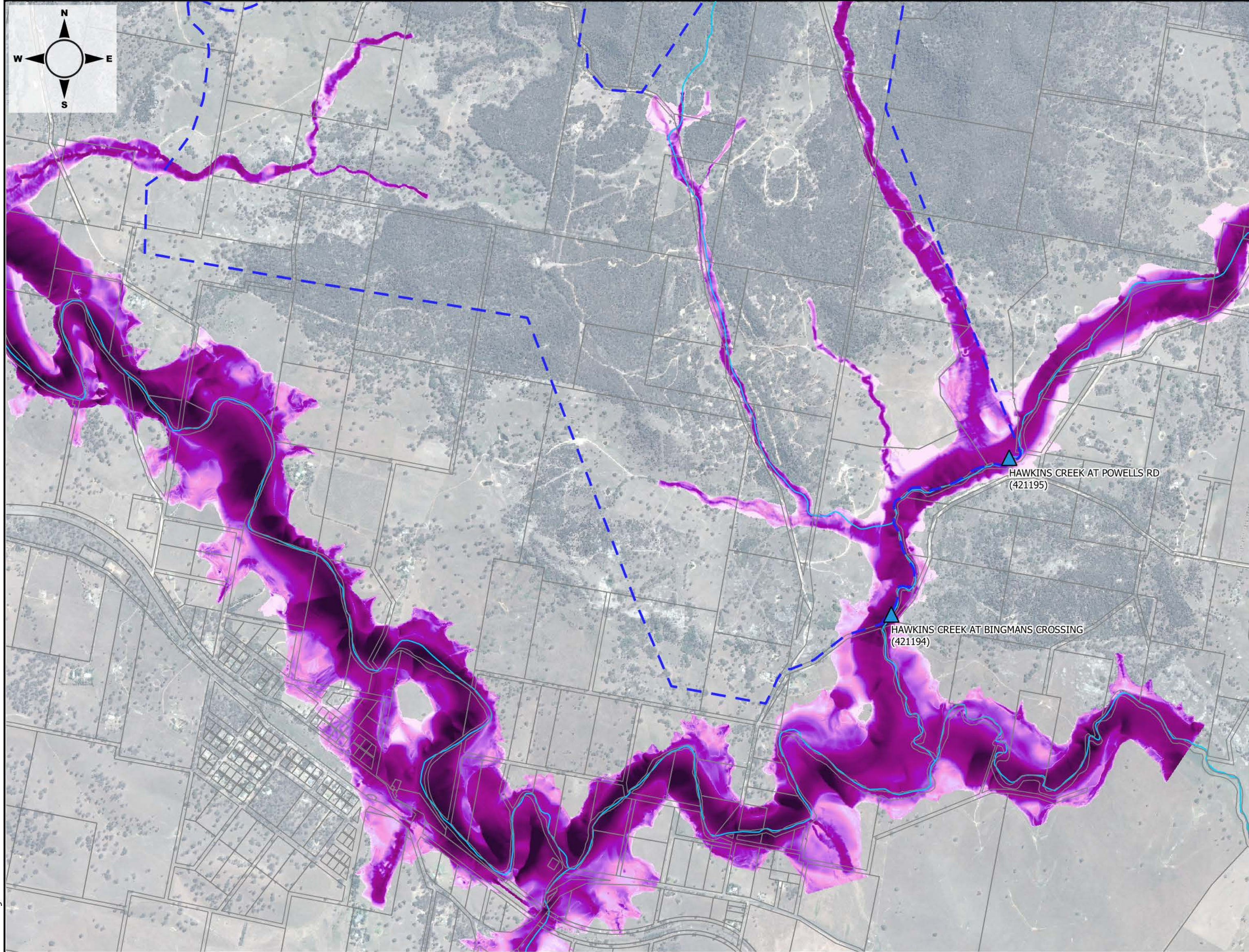
- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 0.2% AEP

wrm water + environment



Legend

- Major watercourse
- Mine Site boundary
- Cadastre
- Streamflow gauge

Velocity

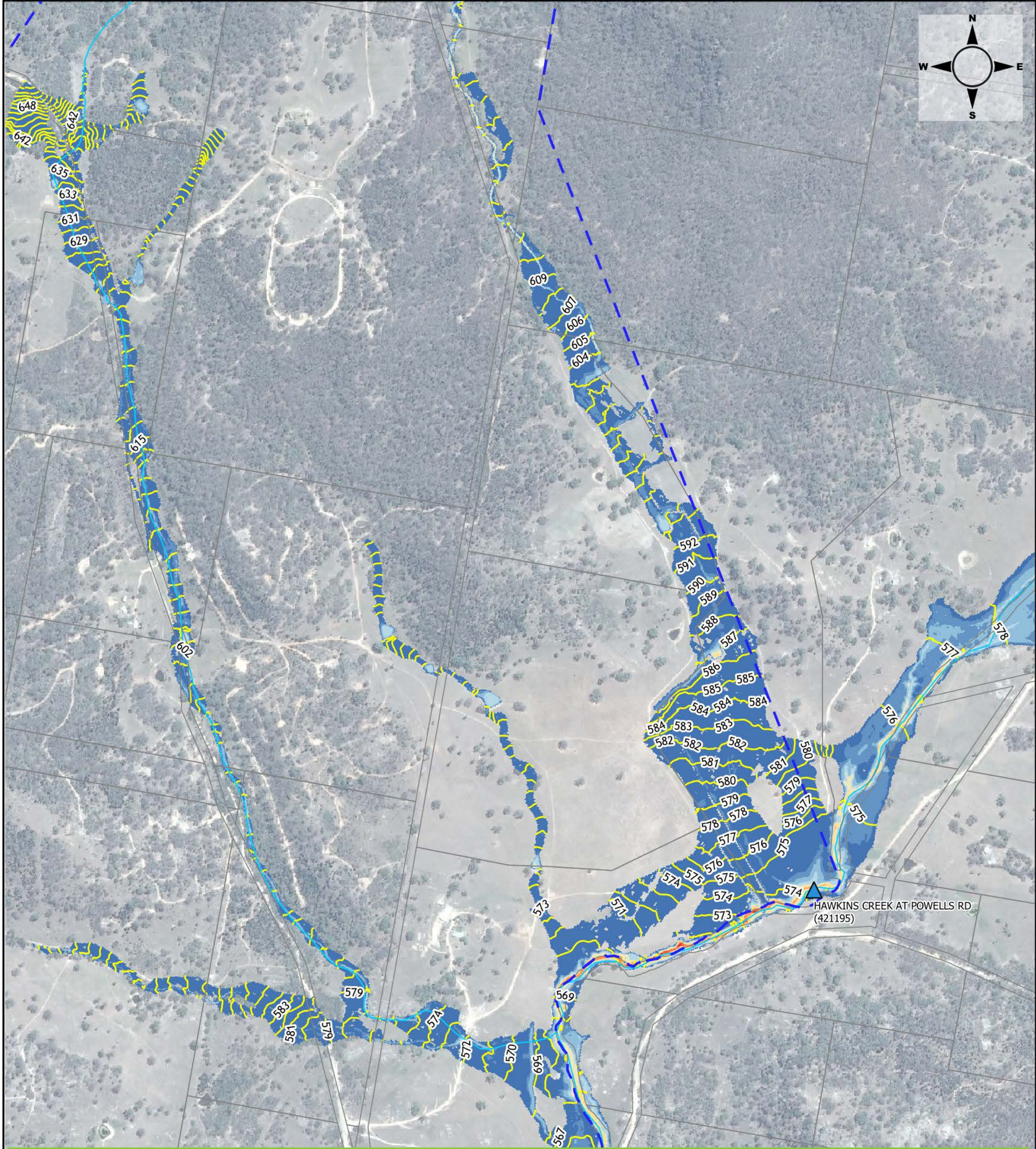
- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), PMF

wrm water+environment



Legend

- ▲ Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 10% AEP

0 200 400 600 m

wrm
water + environment

Projection: MGA Zone 55 Datum: GDA 94

Legend

▲	Streamflow gauge
—	Major watercourse
- -	Mine Site boundary
☐	Cadastre

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 5% AEP

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 2% AEP

0 200 400 600 m

wrm
water + environment

Projection: MGA Zone 55 Datum: GDA 94

Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 1% AEP

0 200 400 600 m

wrm water+environment

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

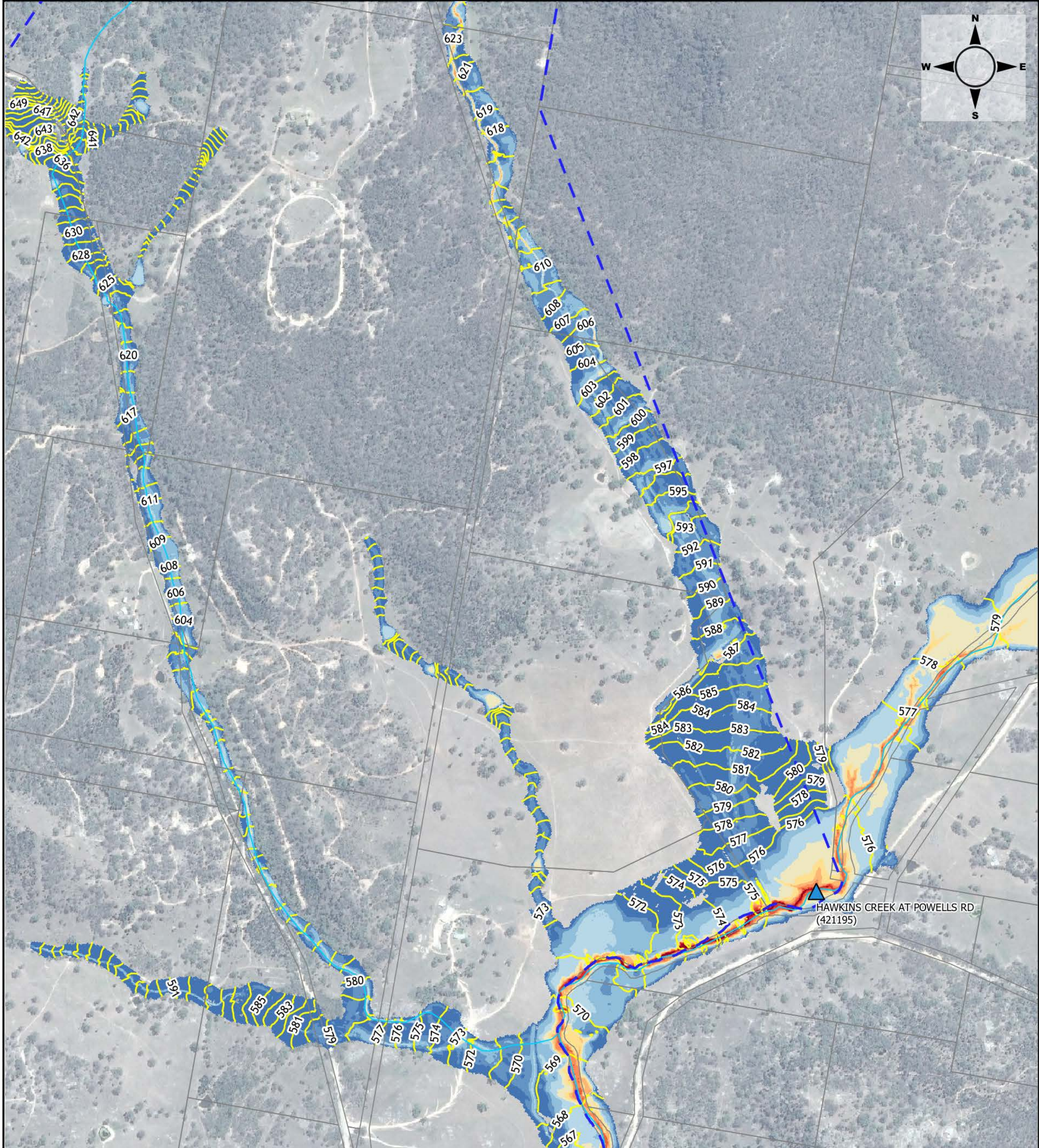
Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 0.5% AEP

0 200 400 600 m

wrm
water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

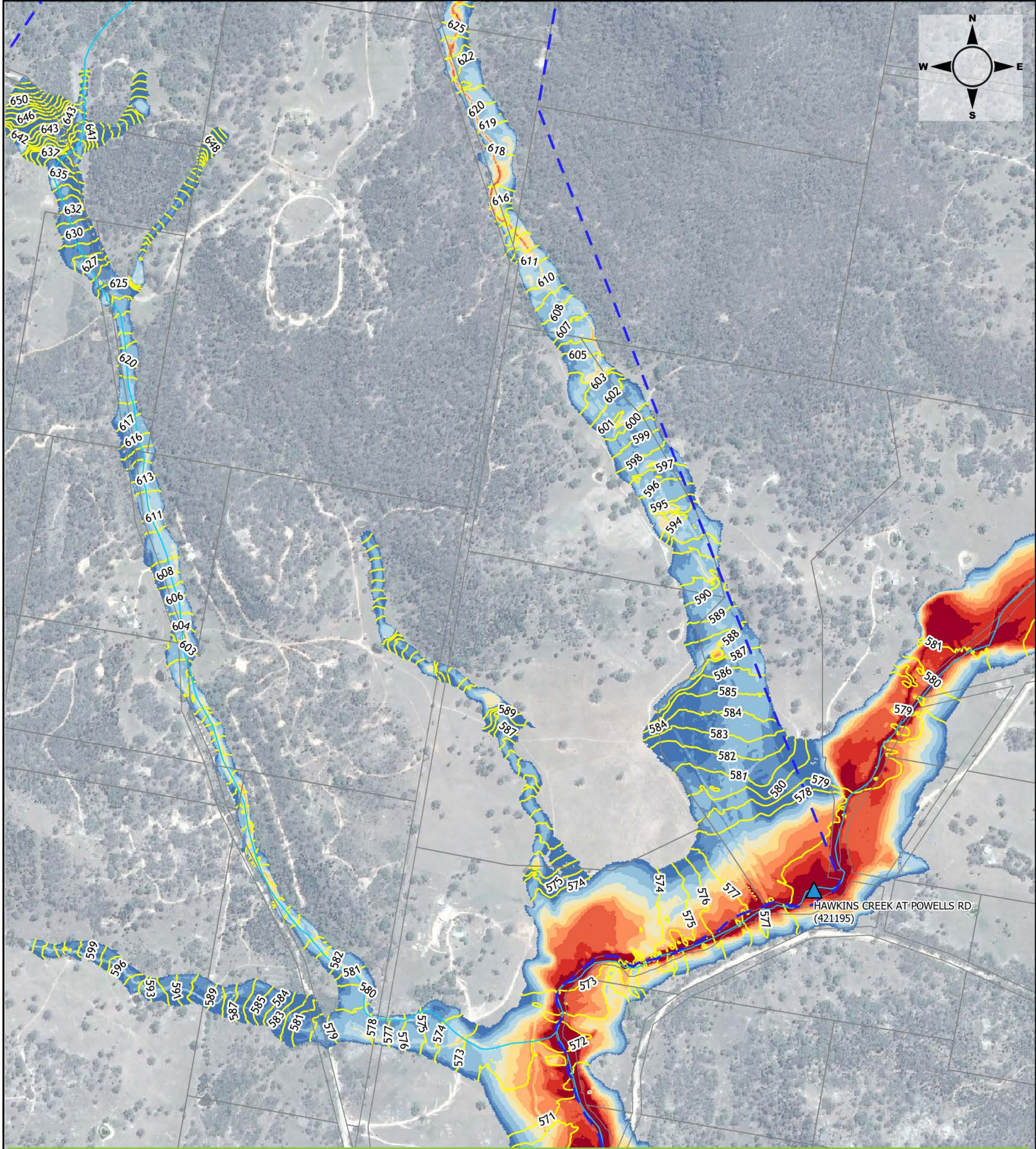
Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 0.2% AEP

0 200 400 600 m

wrm
water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ▲ Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

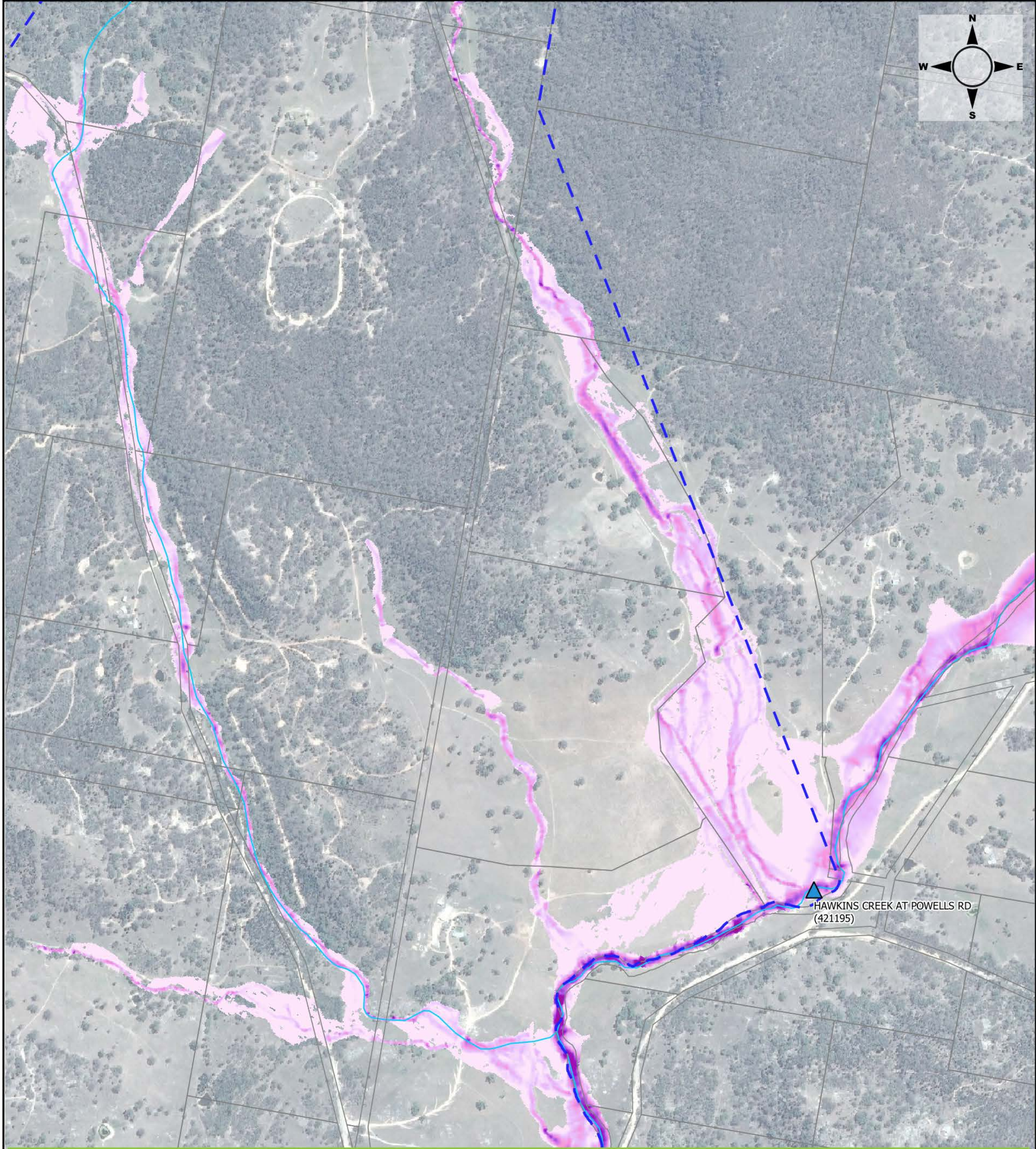
Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), PMF

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

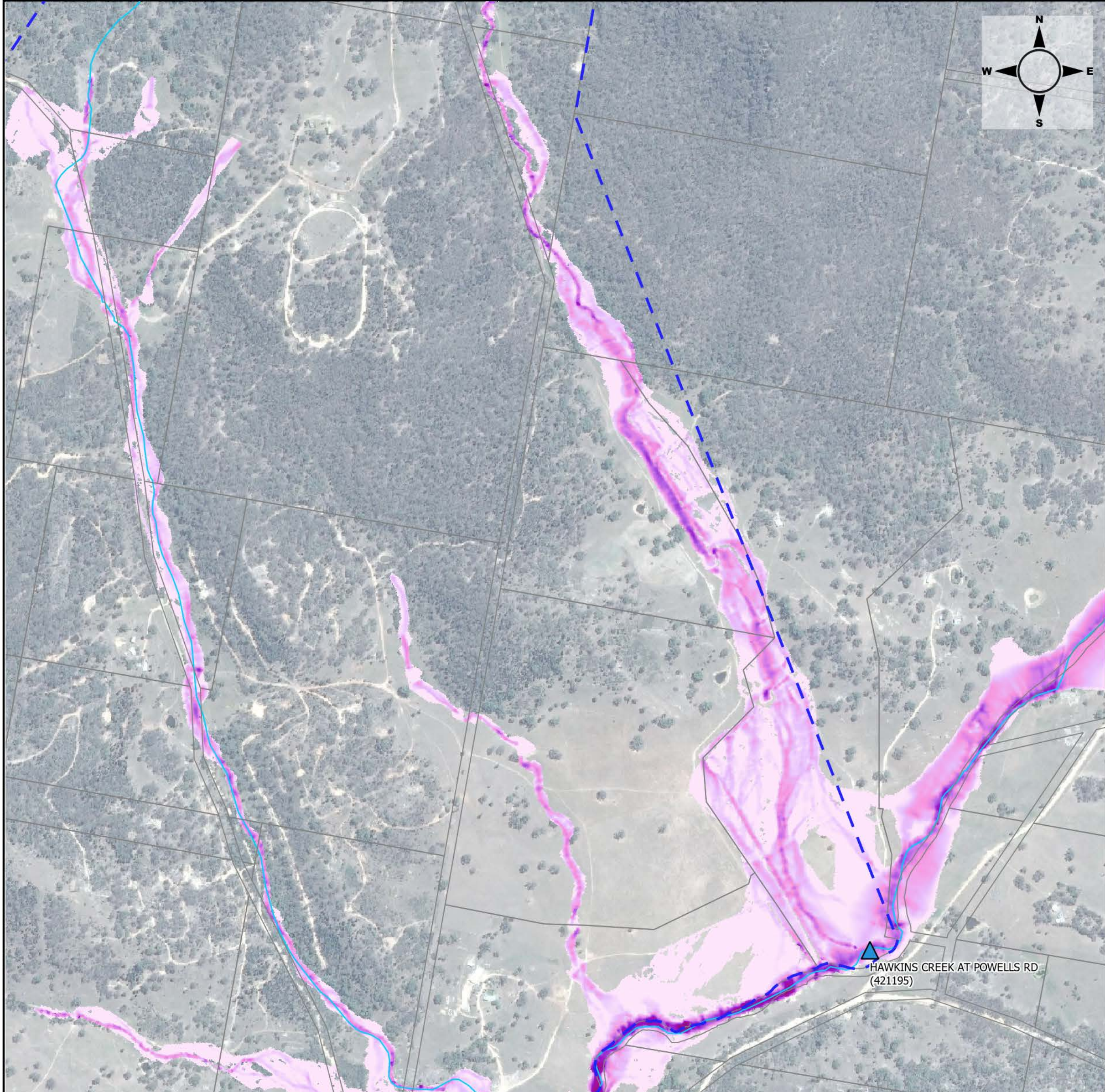
Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 10% AEP

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

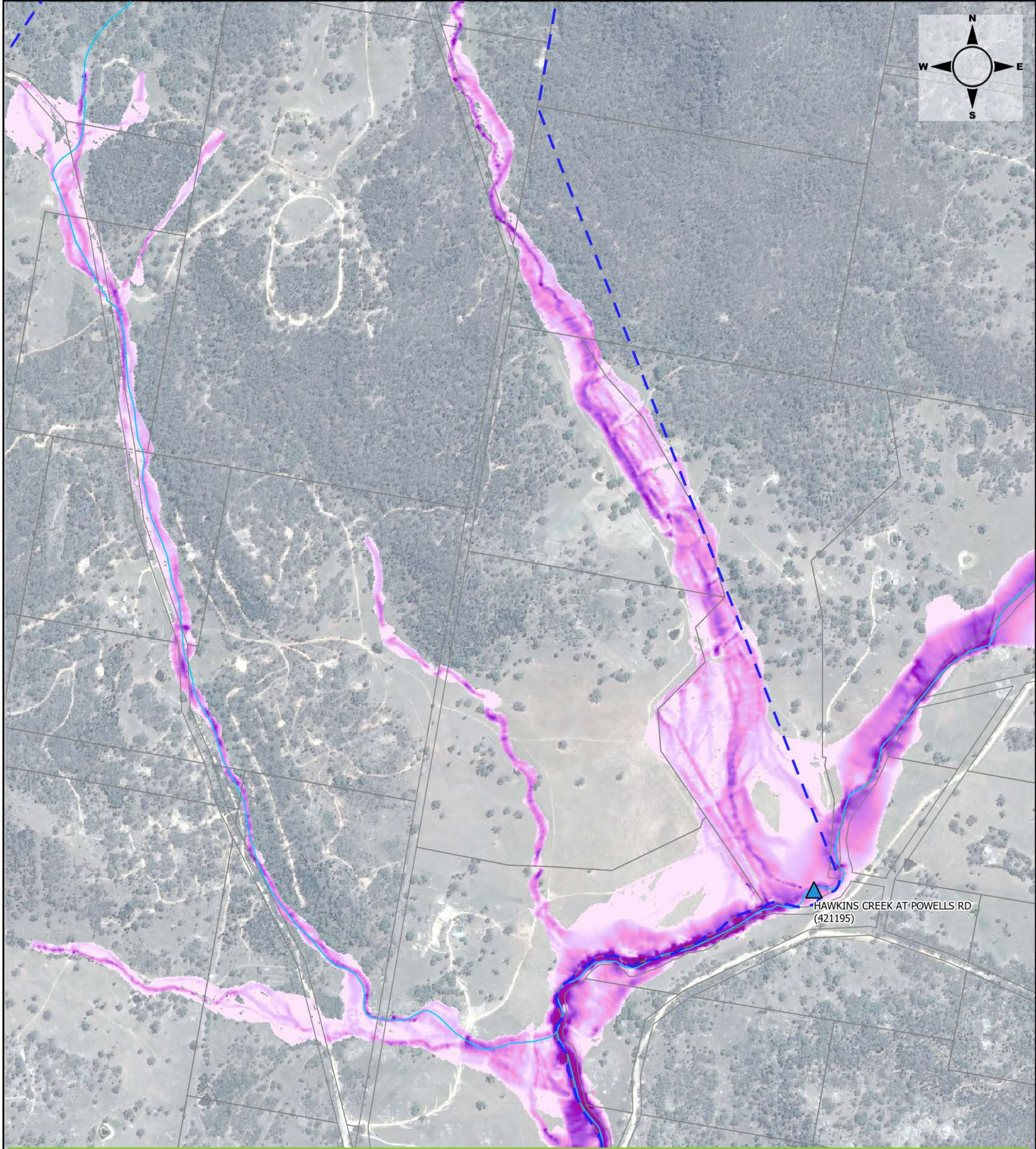
Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 5% AEP

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ▲ Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

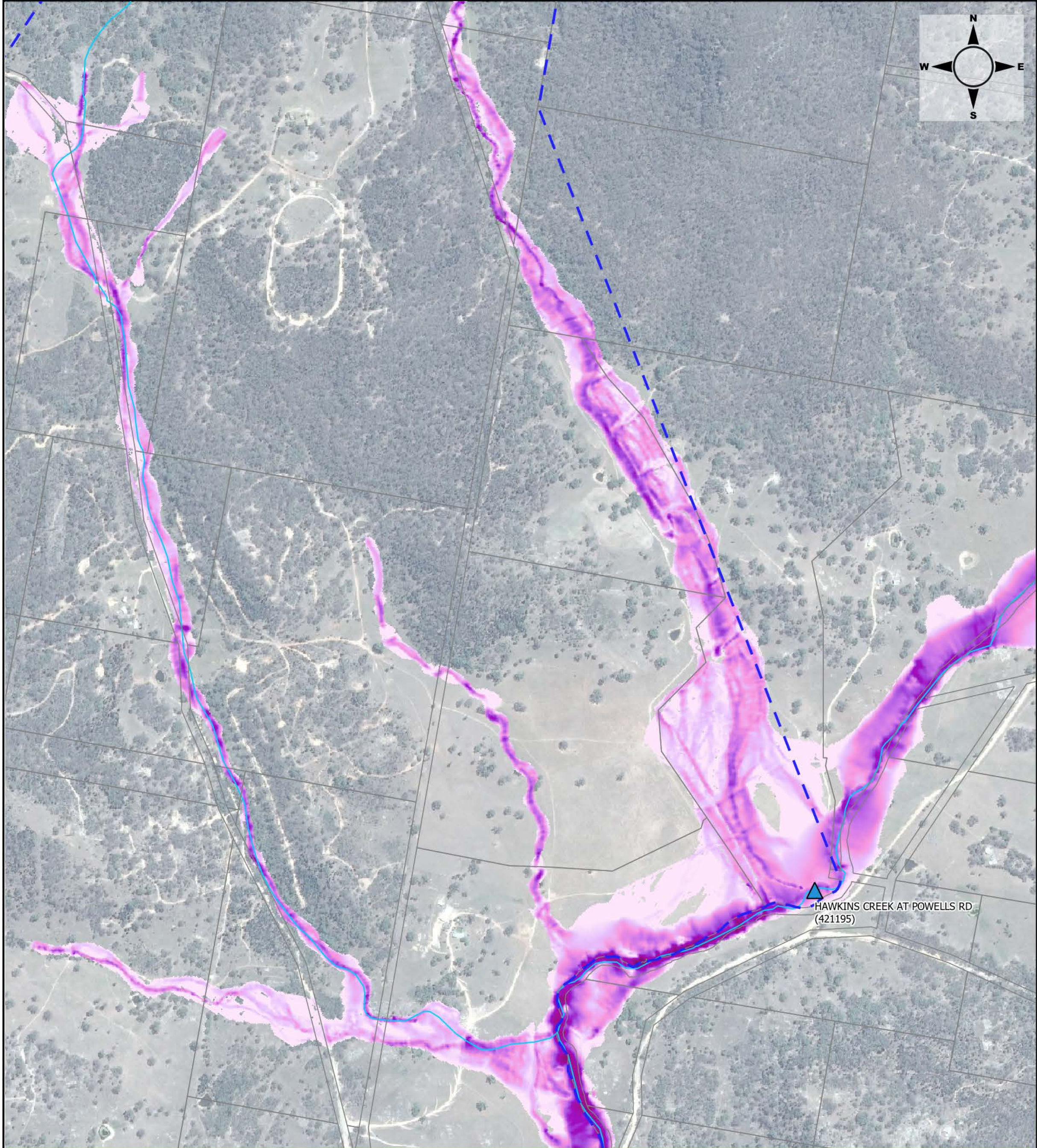
Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 2% AEP

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

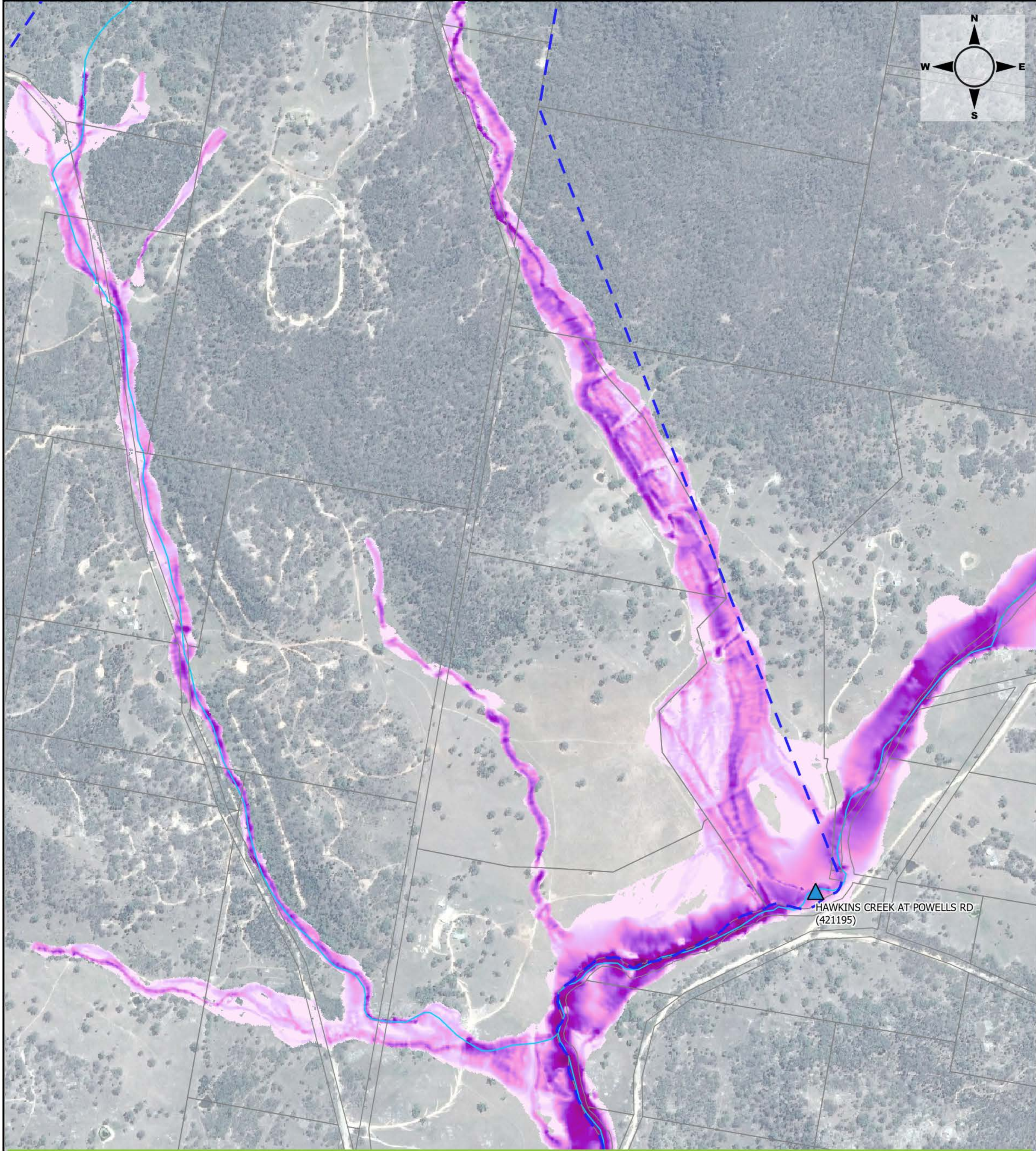
Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 1% AEP

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

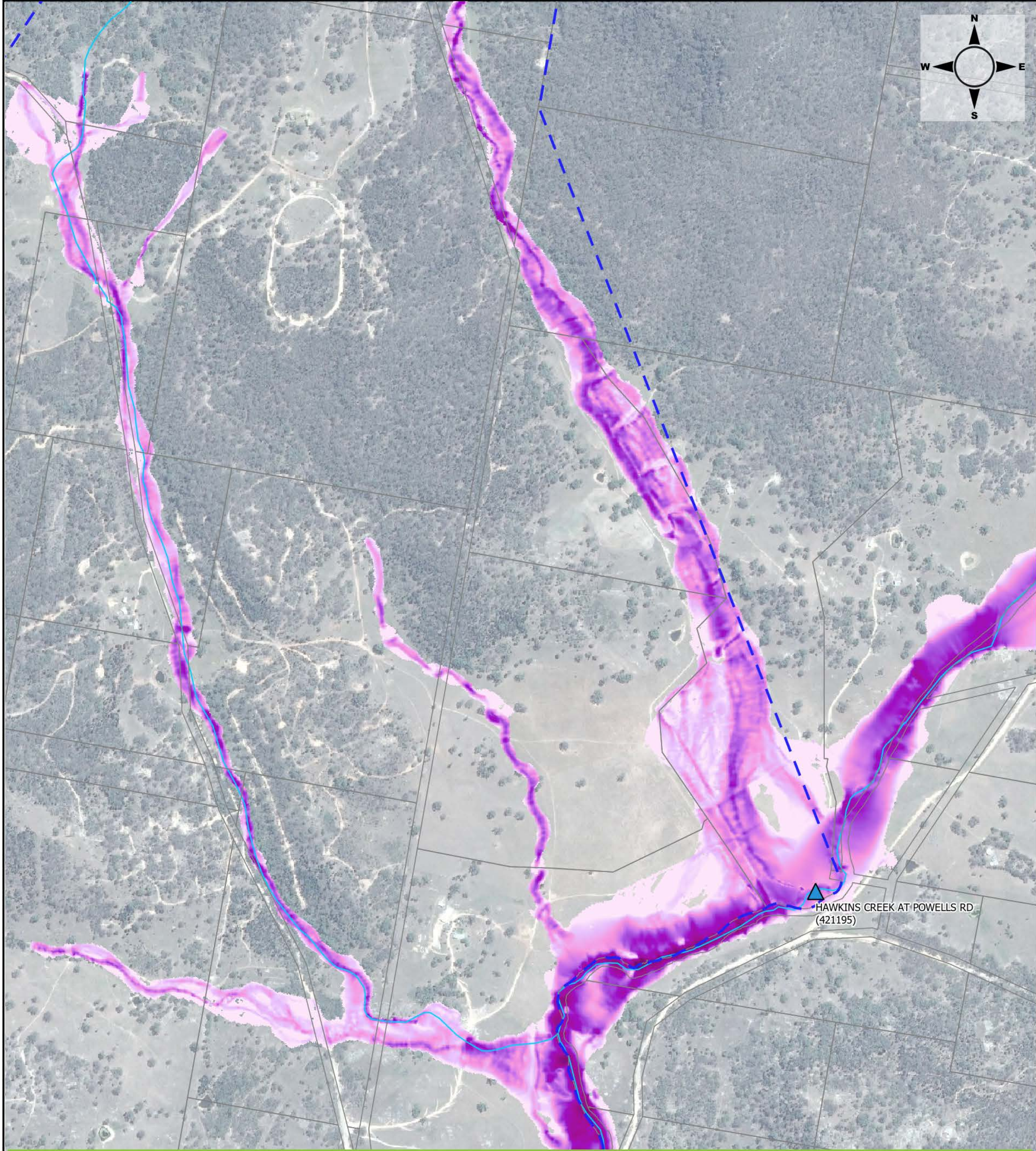
Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 0.5% AEP

0 200 400 600 m

wrm
water + environment

Projection: MGA Zone 55 Datum: GDA 94



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre

Velocity

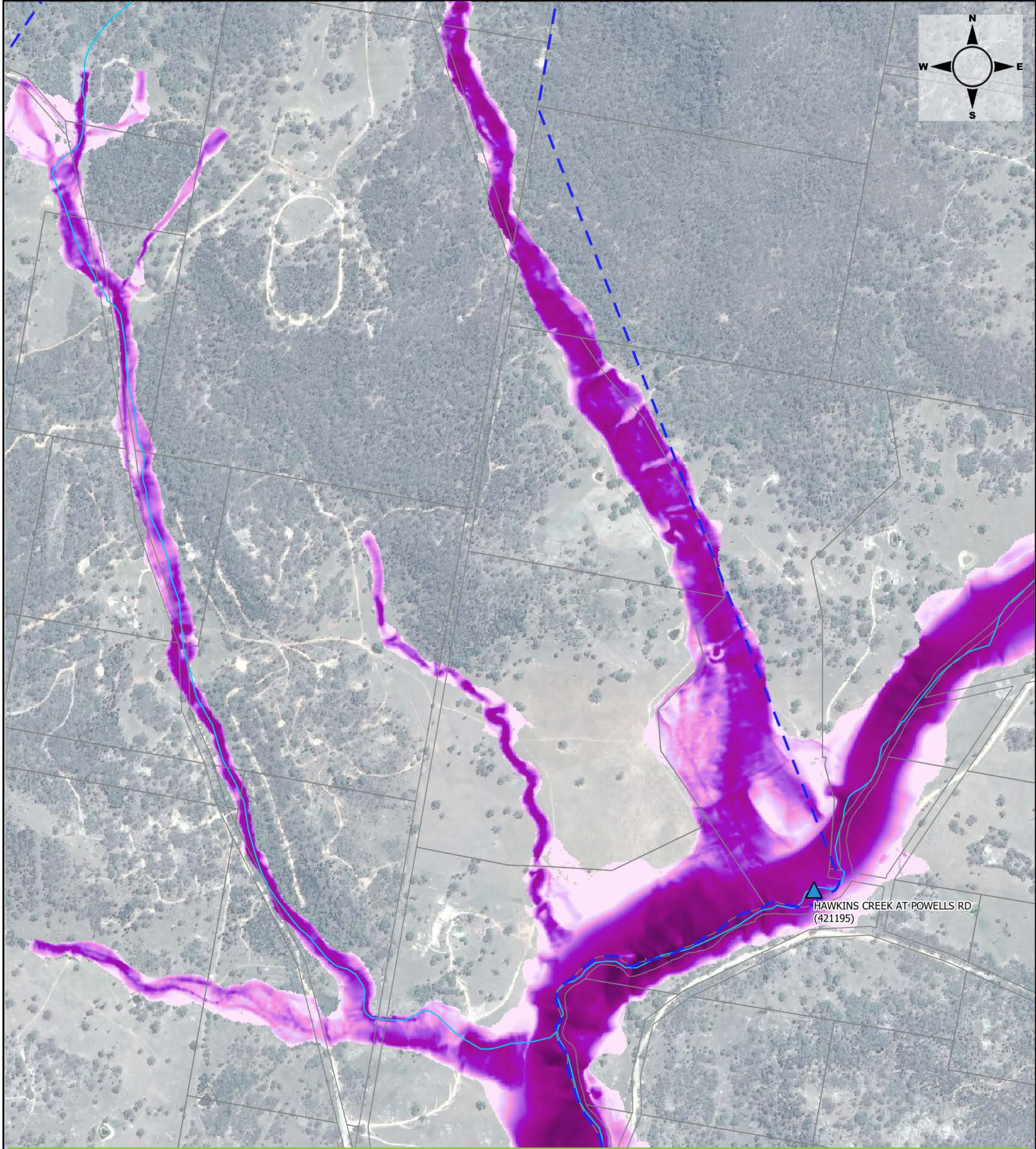
- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 0.2% AEP

0 200 400 600 m

wrm
water + environment



Legend

- ▲ Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

Bowdens Silver Project

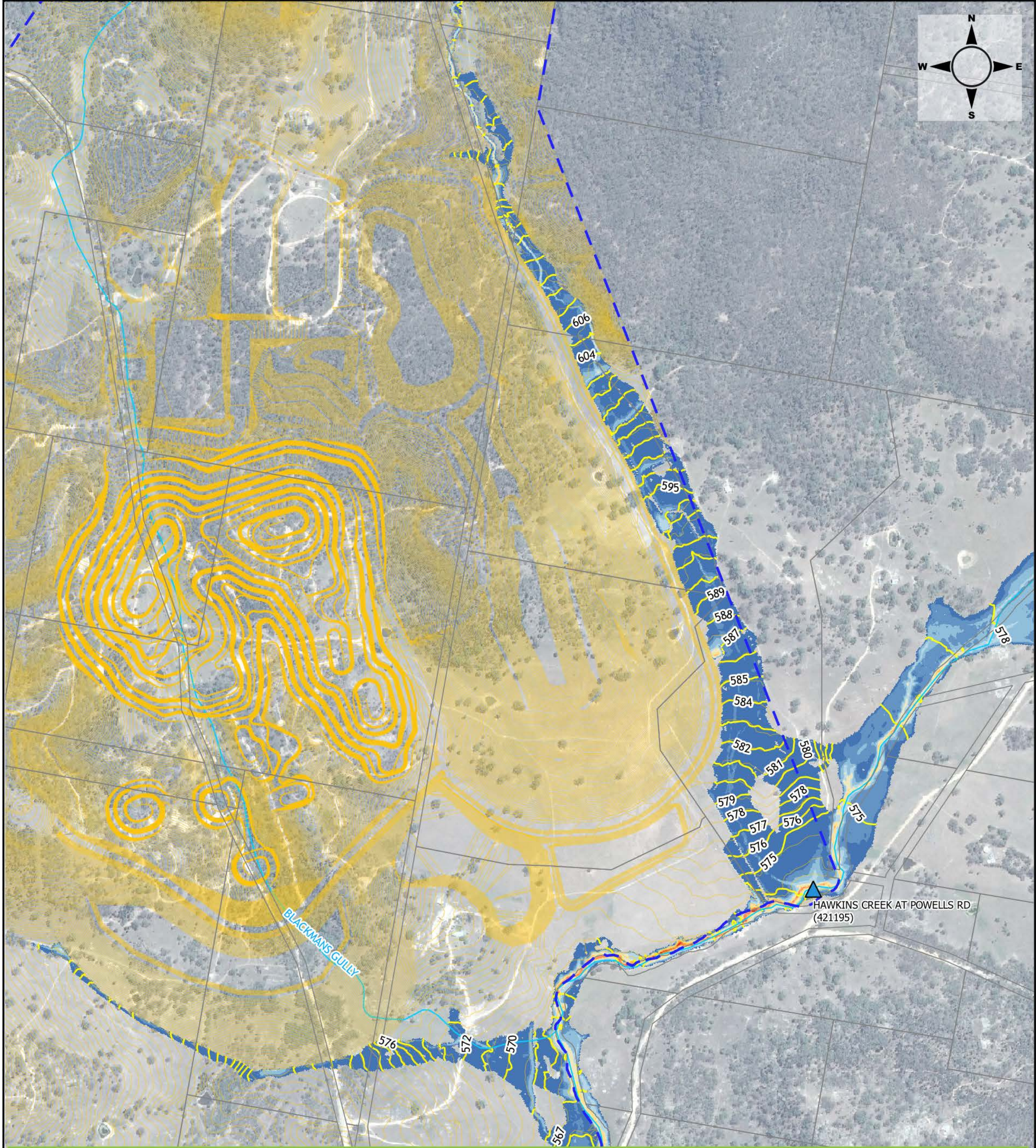
Predicted Flood Velocity (Existing Condition), PMF

0 200 400 600 m

wrm
water + environment

Projection: MGA Zone 55 Datum: GDA 94

Appendix D - Flood maps - Maximum disturbance scenario



Legend

- ▲ Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

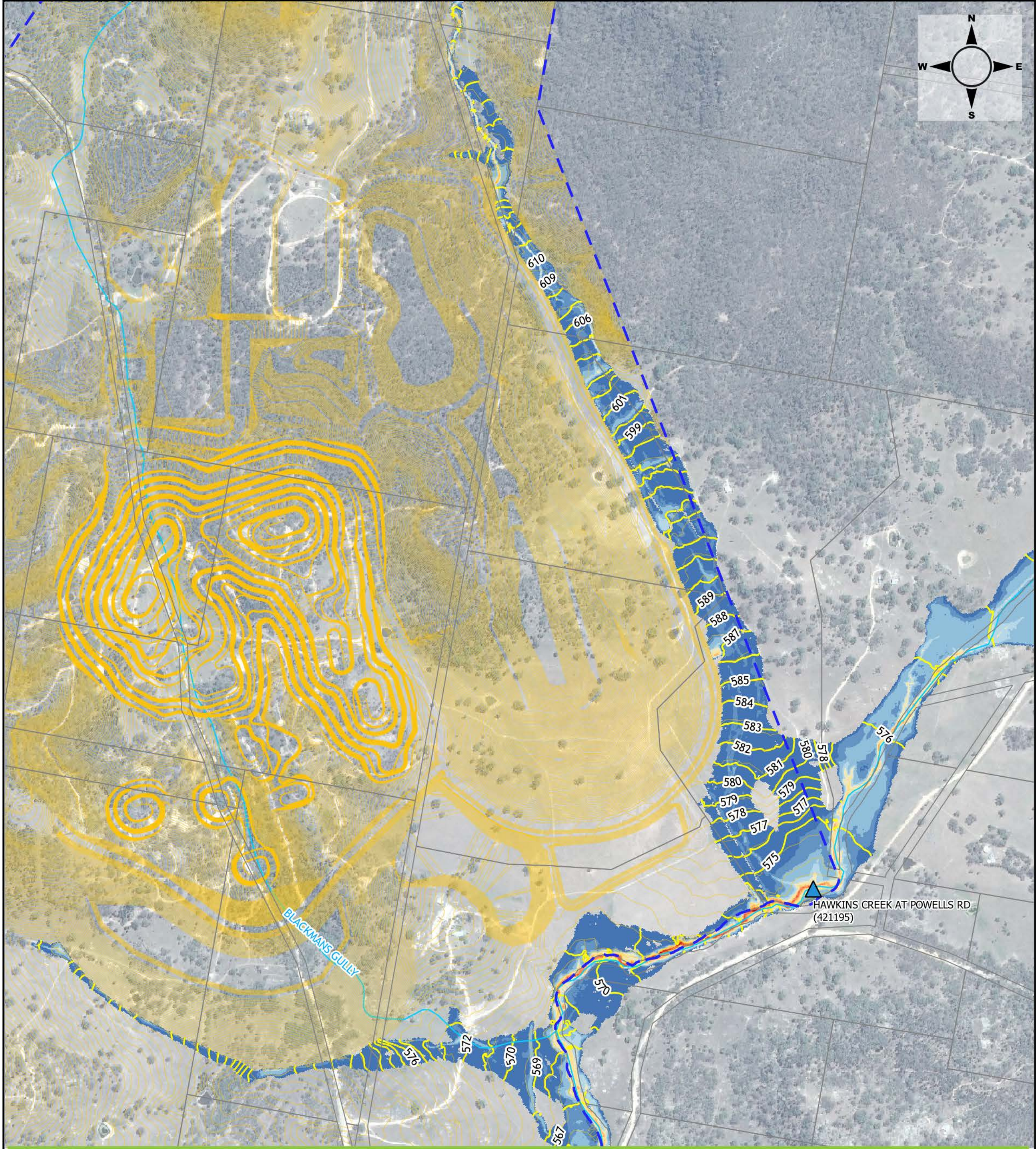
Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), 10% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

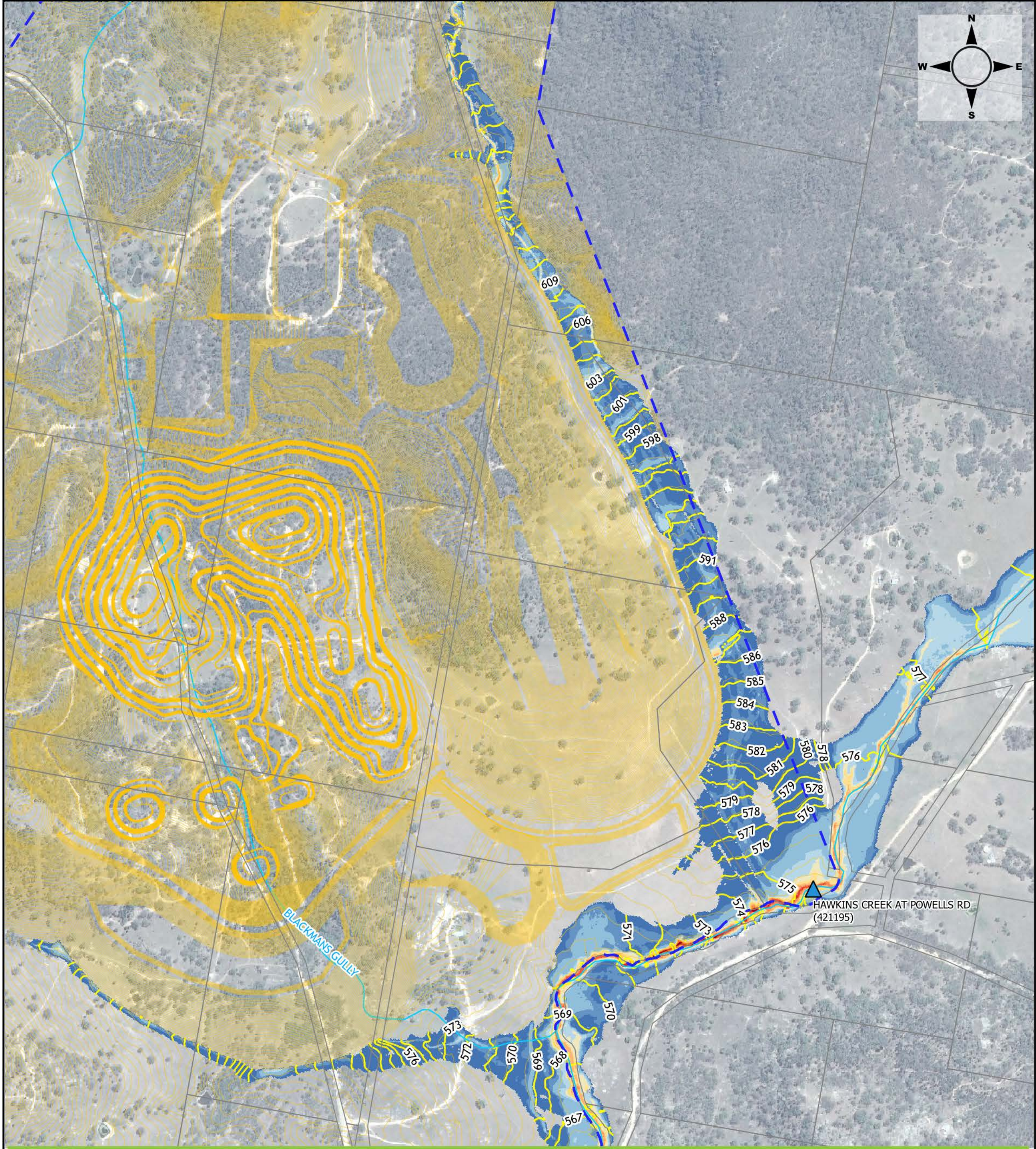
Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), 5% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

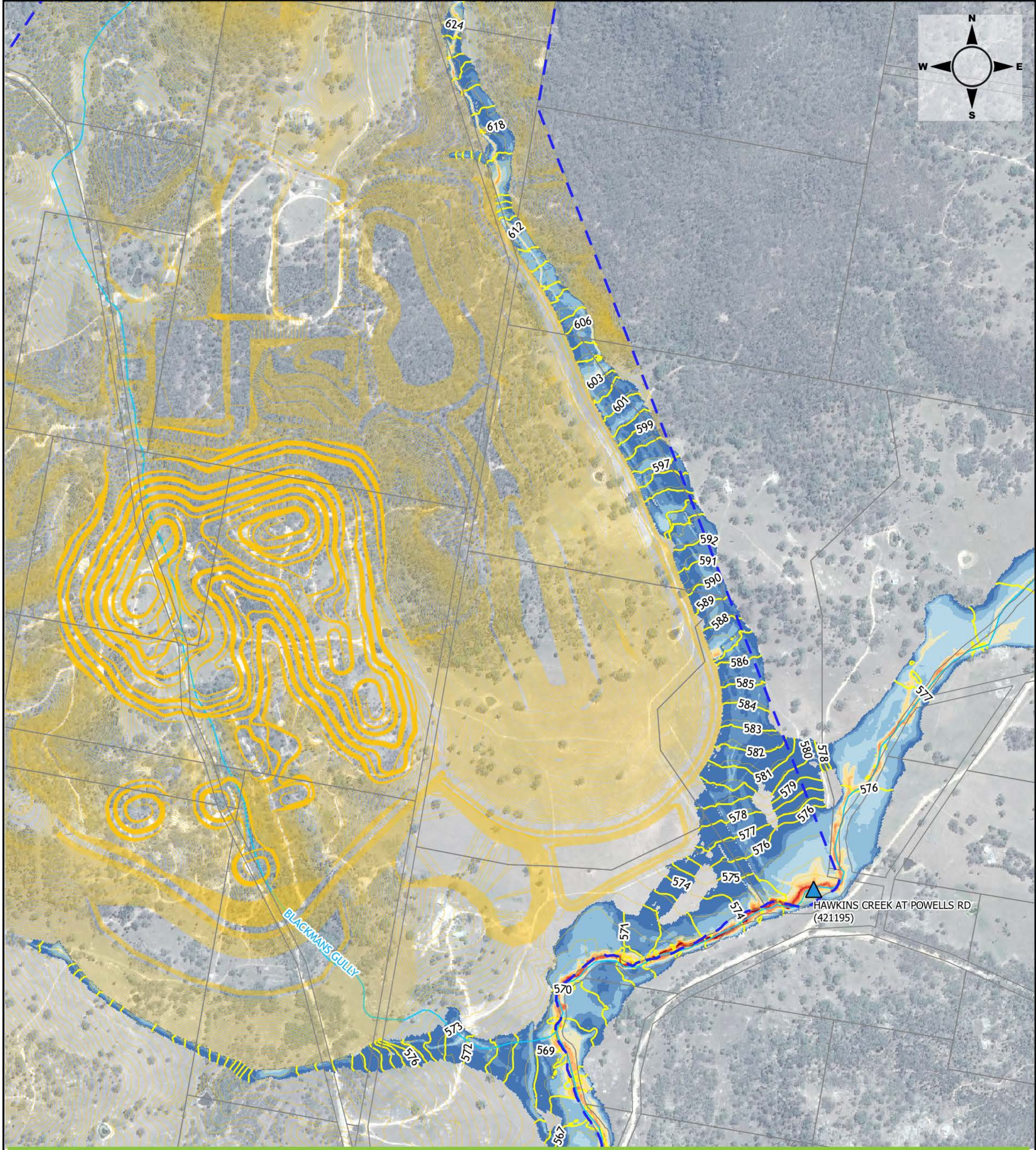
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), 2% AEP, WRE Stage 7

0 200 400 600 m

wrm
water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

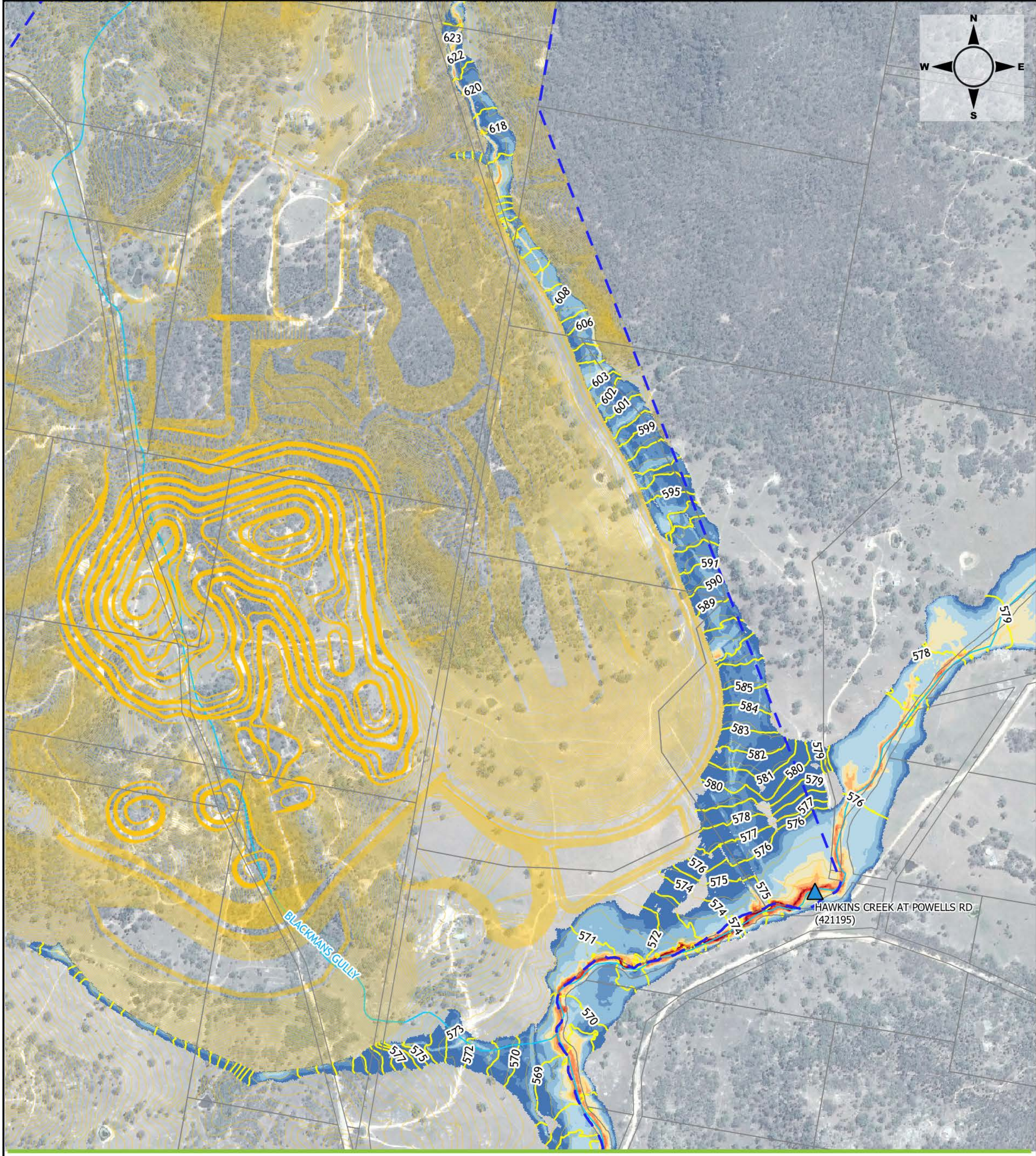
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), 1% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

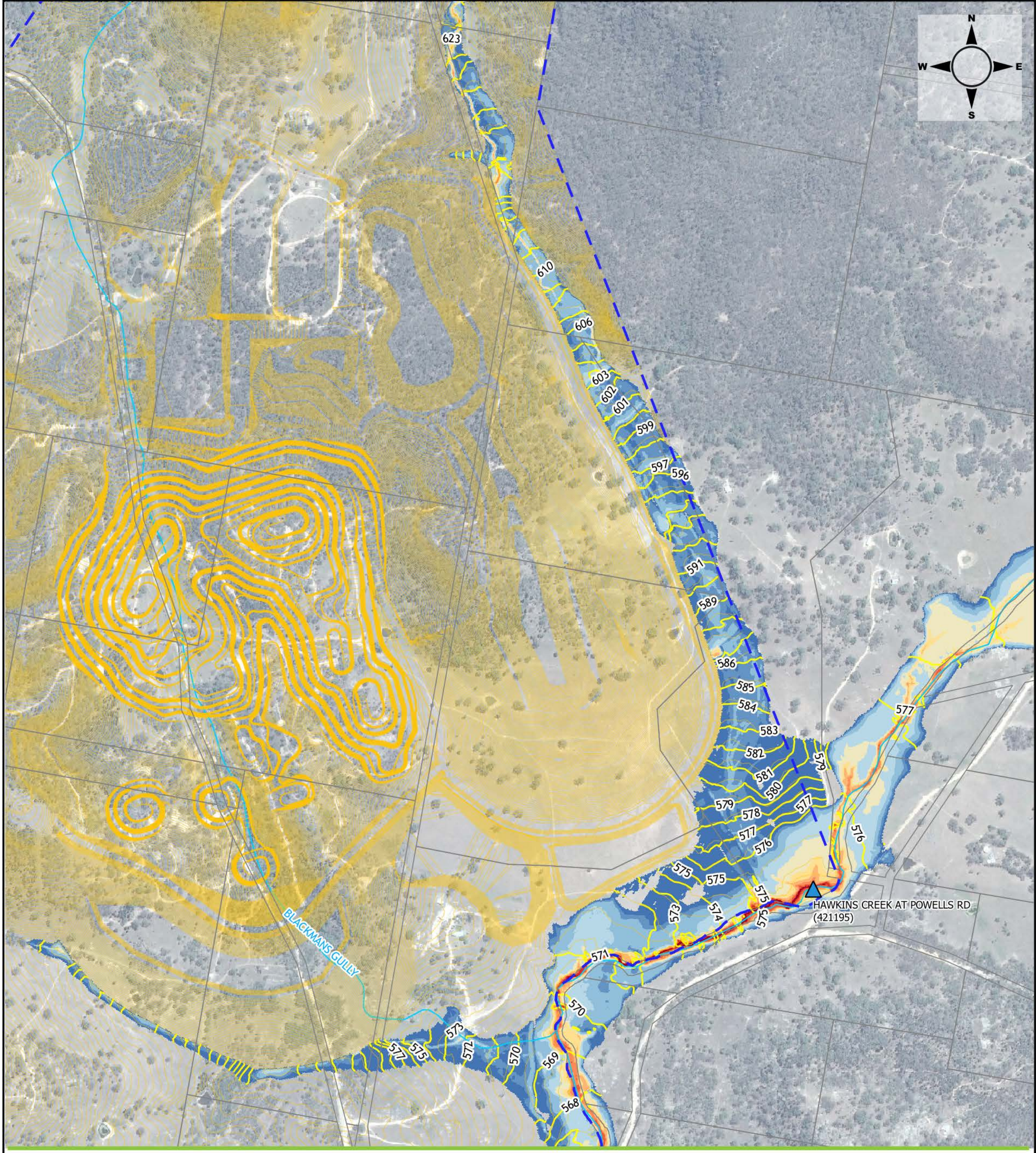
Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), 0.5% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

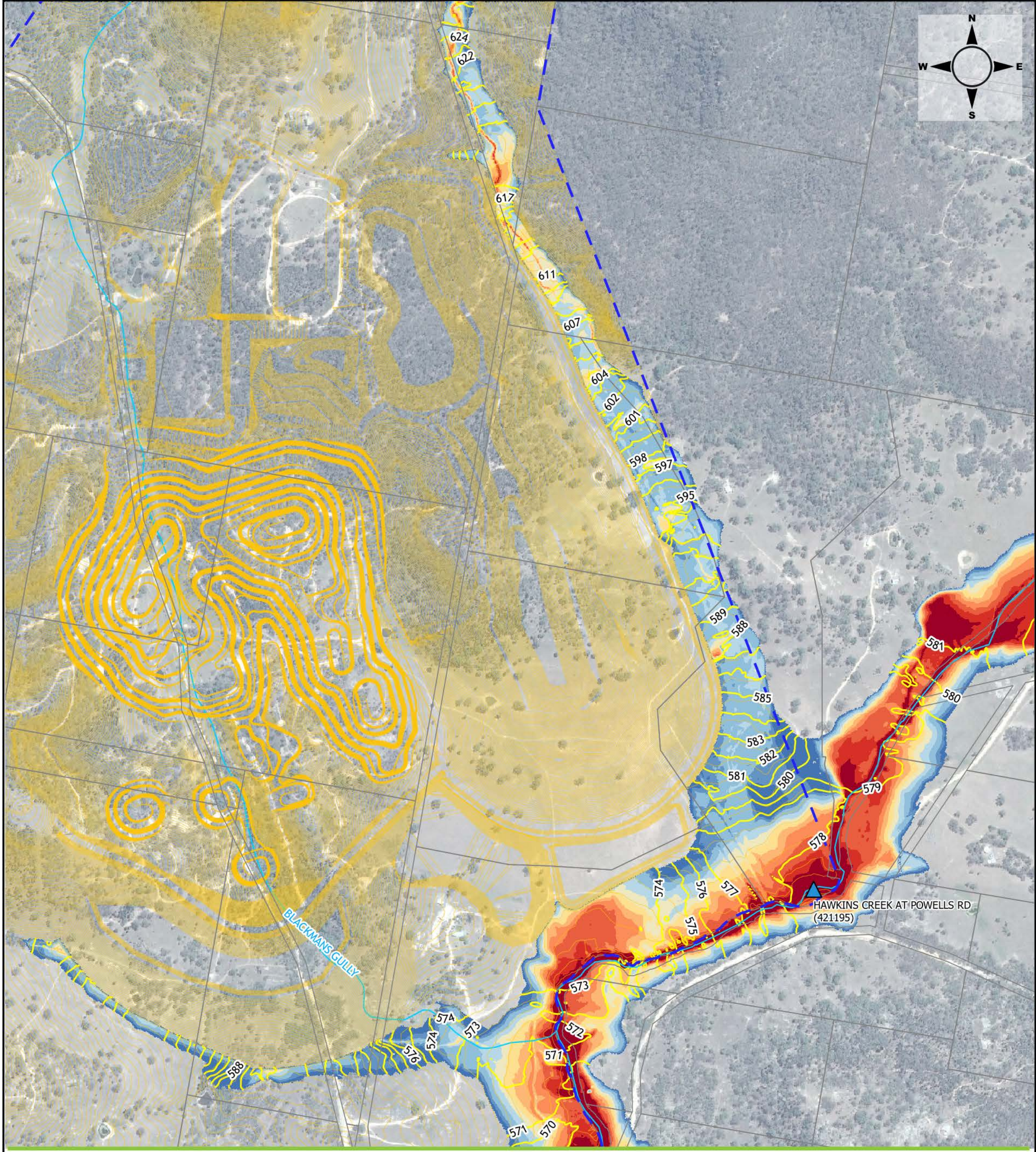
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), 0.2% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

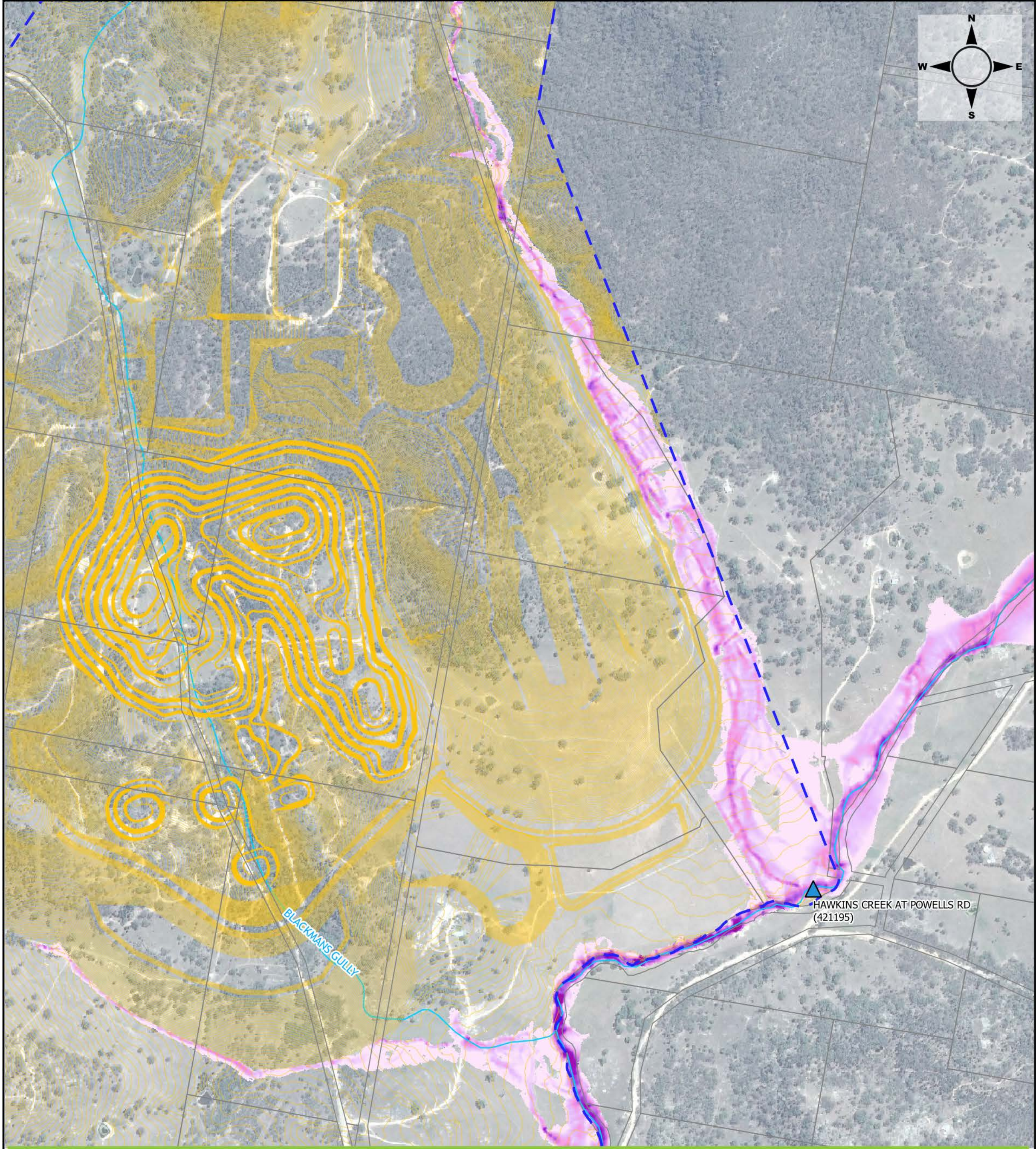
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), PMF, WRE Stage 7

0 200 400 600 m

wrm water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Velocity

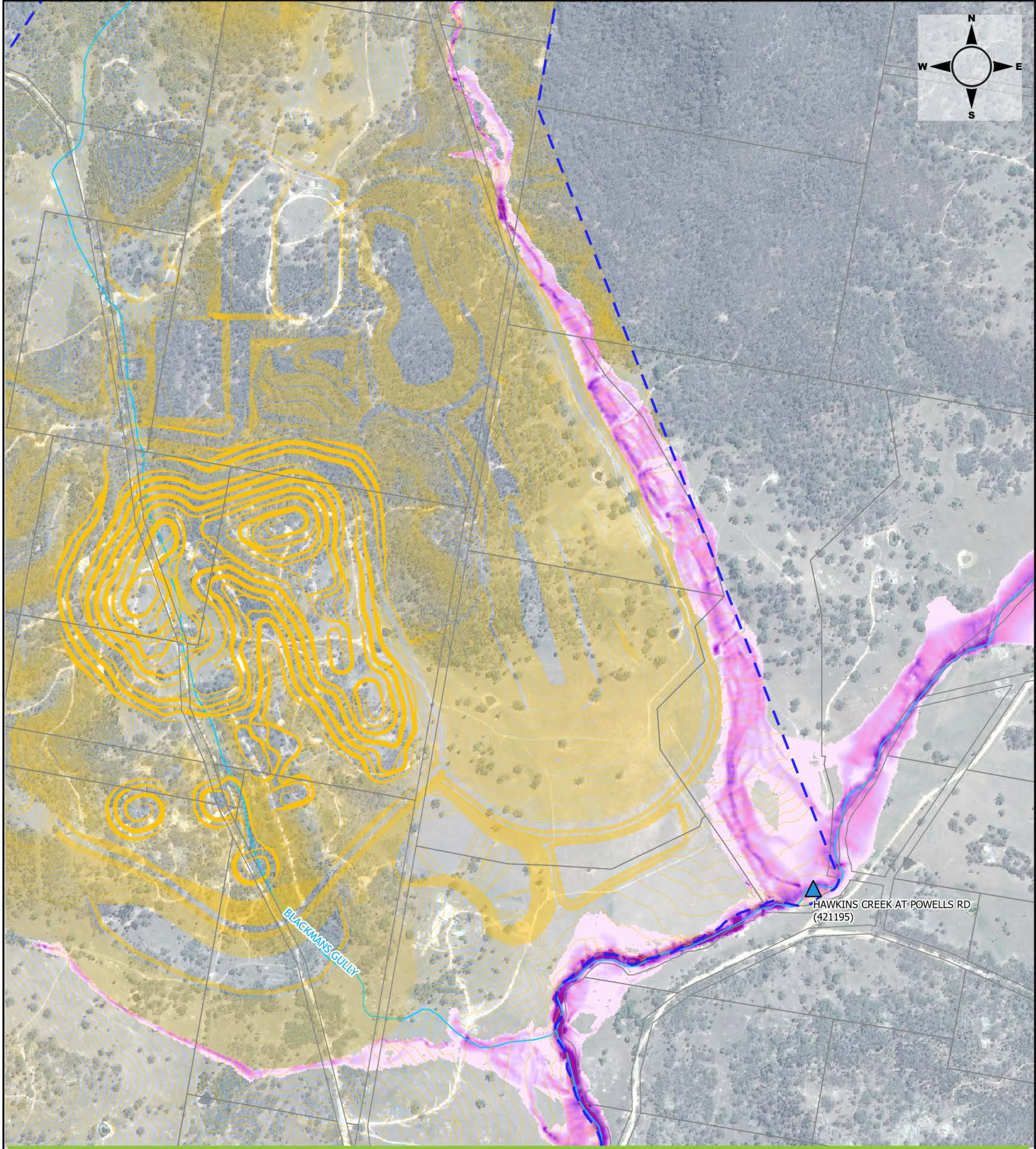
- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

Bowdens Silver Project

Predicted Flood Velocity (Developed Condition), 10% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

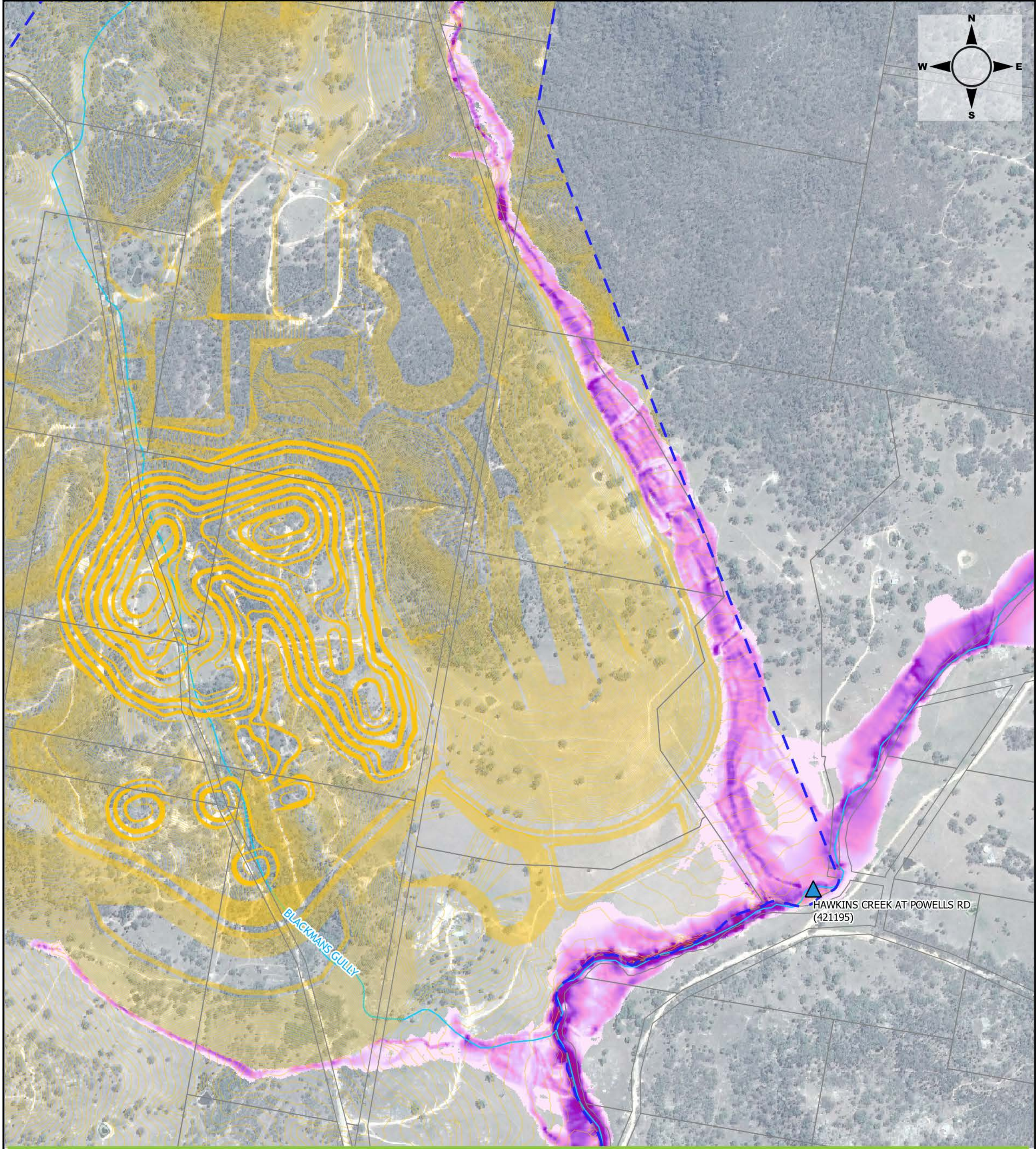
Bowdens Silver Project

Predicted Flood Velocity (Developed Condition), 5% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

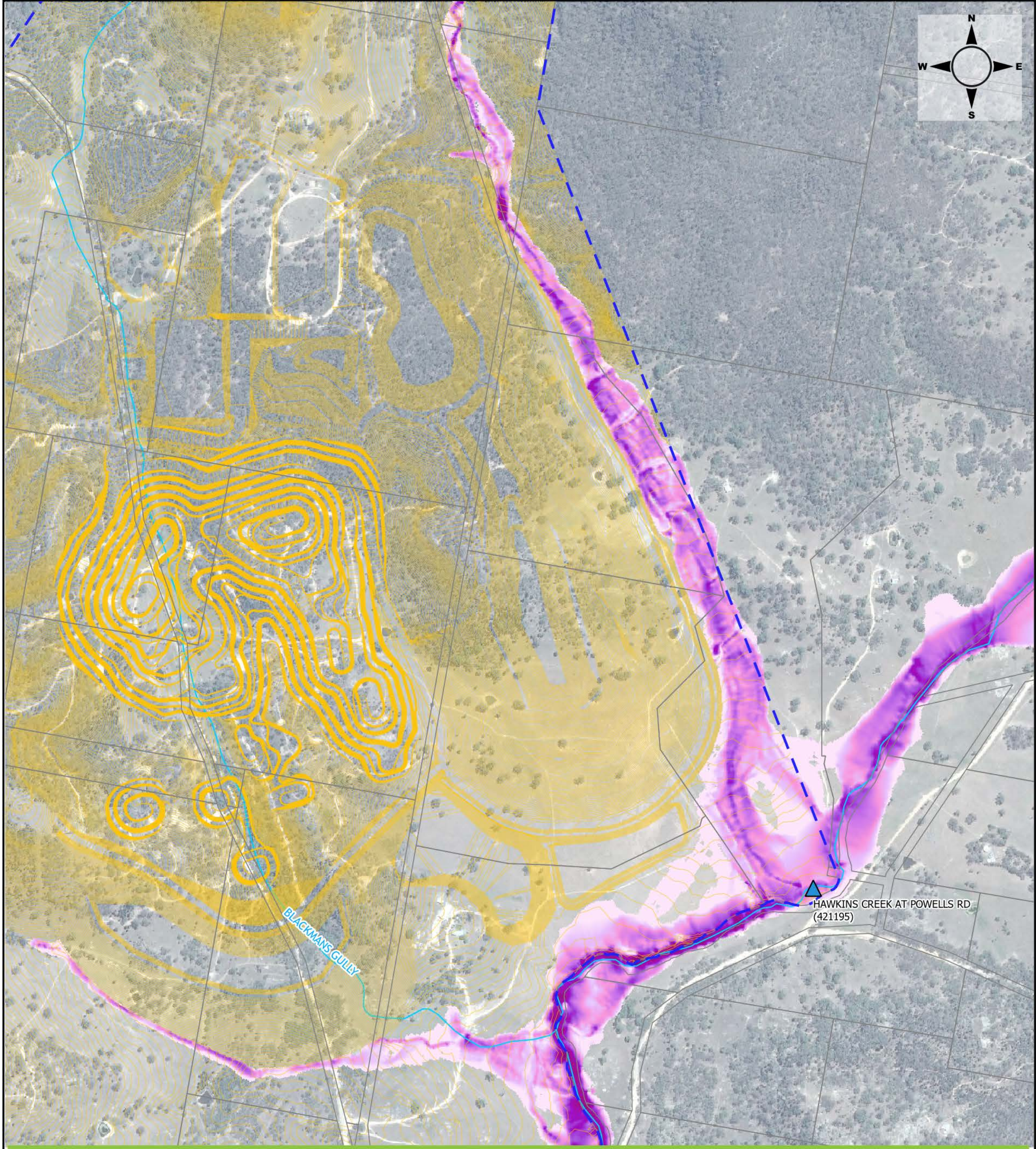
Bowdens Silver Project

Predicted Flood Velocity (Developed Condition), 2% AEP, WRE Stage 7

0 200 400 600 m

wrm
water + environment

Projection: MGA Zone 55 Datum: GDA 94



Datum: GDA 94
Projection: MGA Zone 55

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Velocity

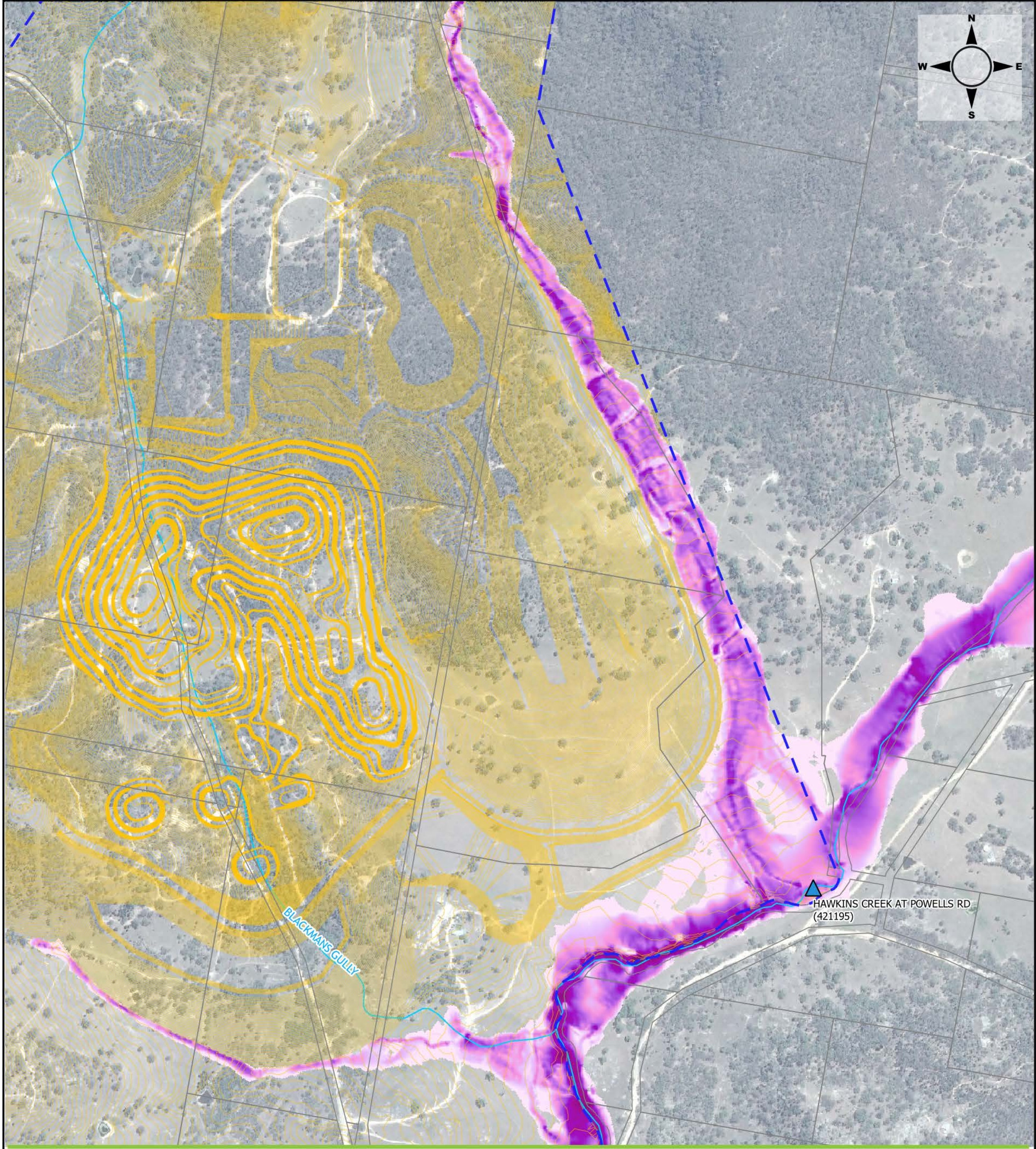
- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

Bowdens Silver Project

Predicted Flood Velocity (Developed Condition), 1% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Velocity

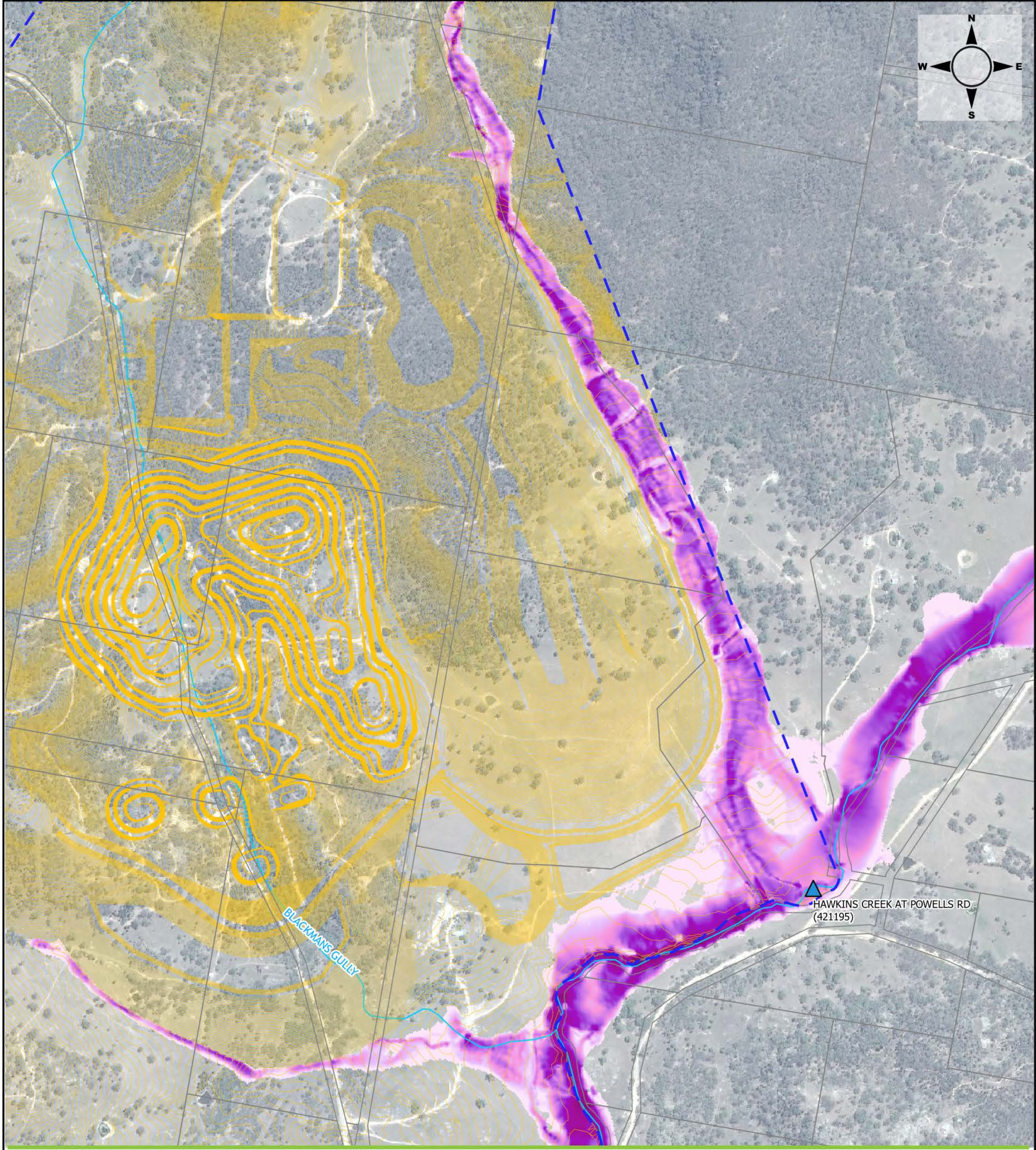
- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

Bowdens Silver Project

Predicted Flood Velocity (Developed Condition), 0.5% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Velocity

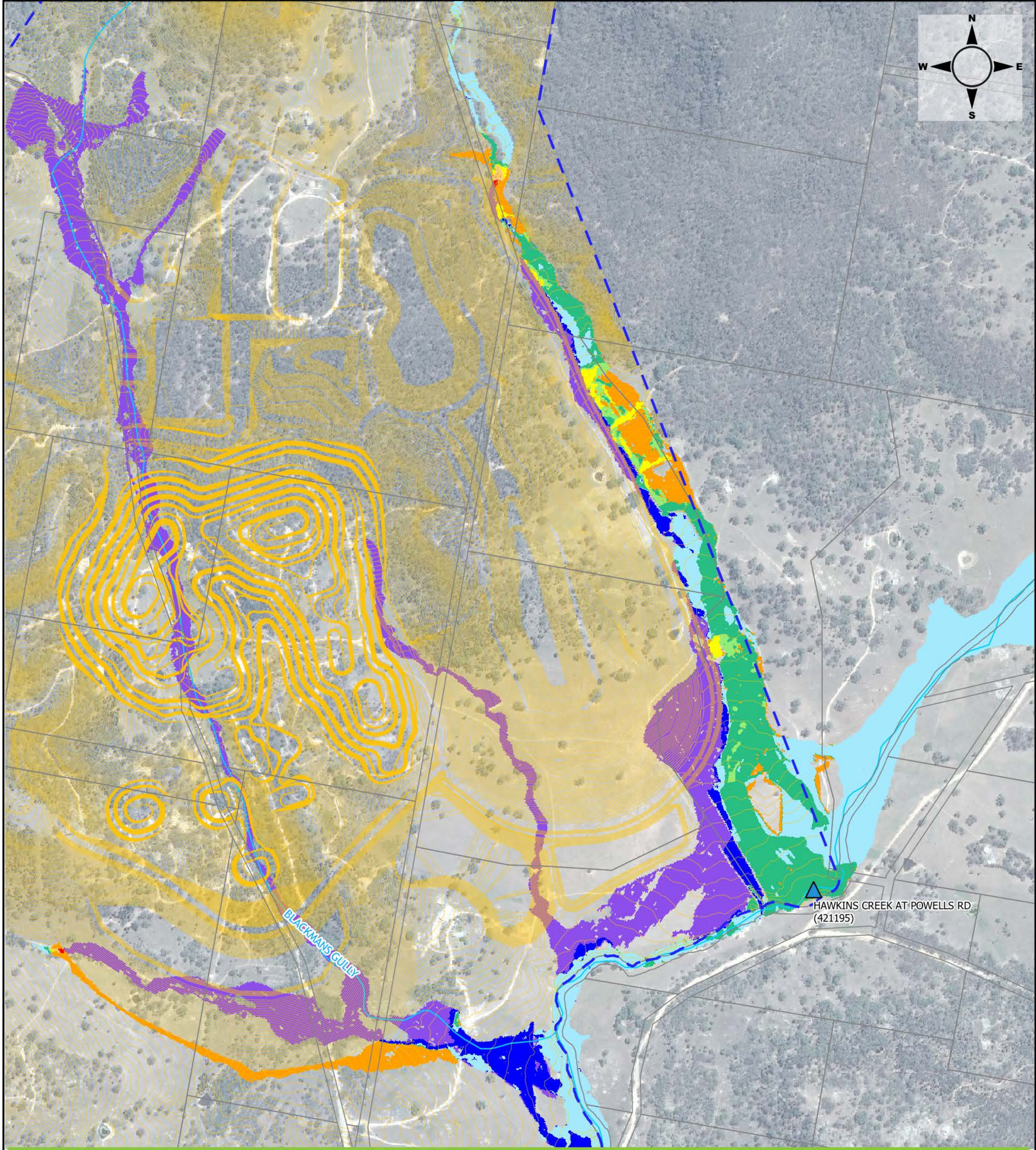
- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

Bowdens Silver Project

Predicted Flood Velocity (Developed Condition), 0.2% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment



Legend

- ▲ Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak water level

- < -1.00 m
- -1.00 m to -0.01 m
- -0.01 m to 0.01 m
- 0.01 m to 0.05 m
- 0.05 m to 0.10 m
- 0.10 m to 0.50 m
- 0.50 m to 1.00 m
- 1.00 m to 2.00 m
- 2.00 m to 3.00 m
- 3.00 m to 5.00 m
- > 5.00 m

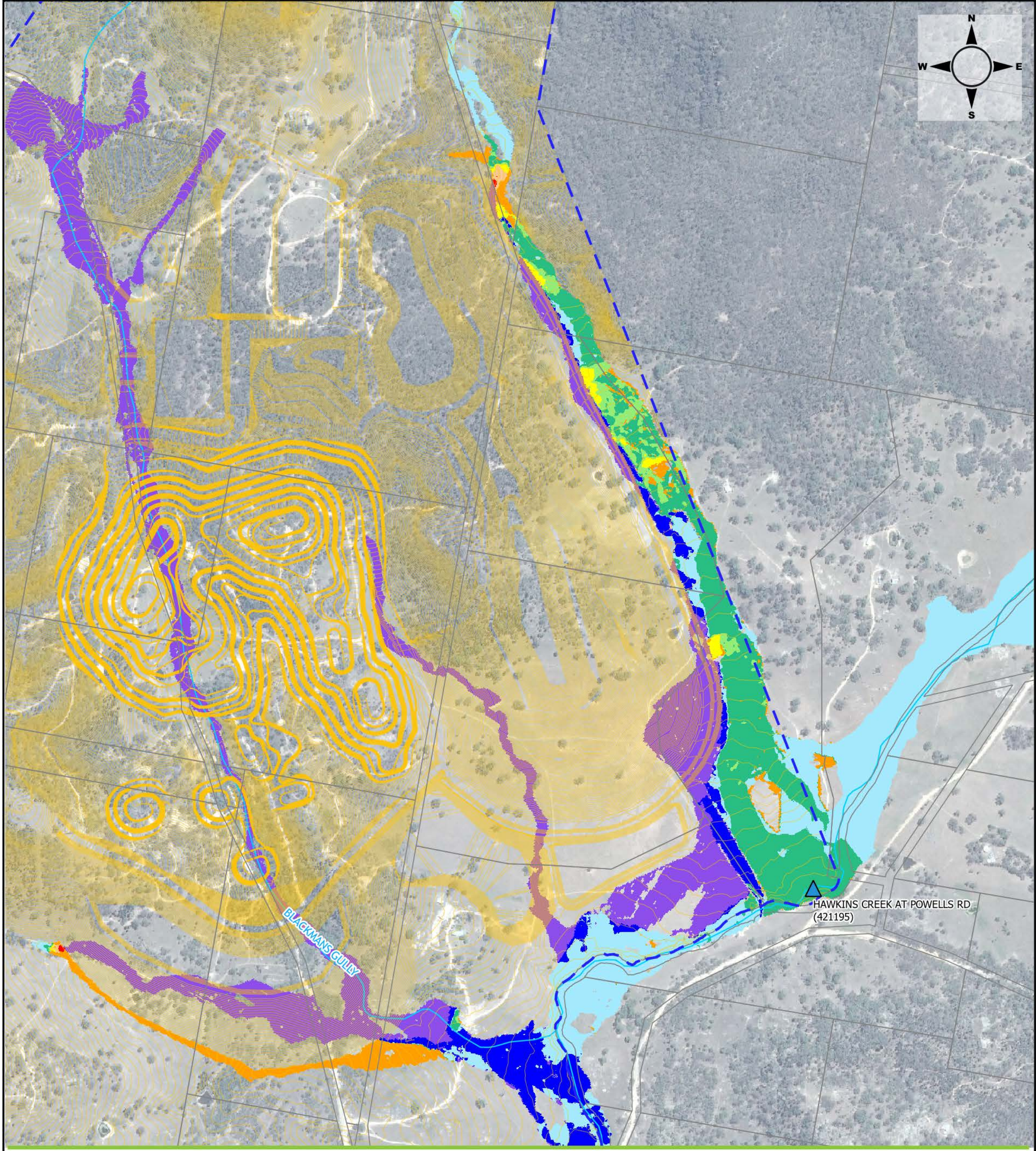
Bowdens Silver Project

Change in Peak Water Level,
10% AEP, WRE Stage 7

0 200 400 600 m

wrm
water + environment

Projection: MGA Zone 55 Datum: GDA 94



Projection: MGA Zone 55   Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak water level

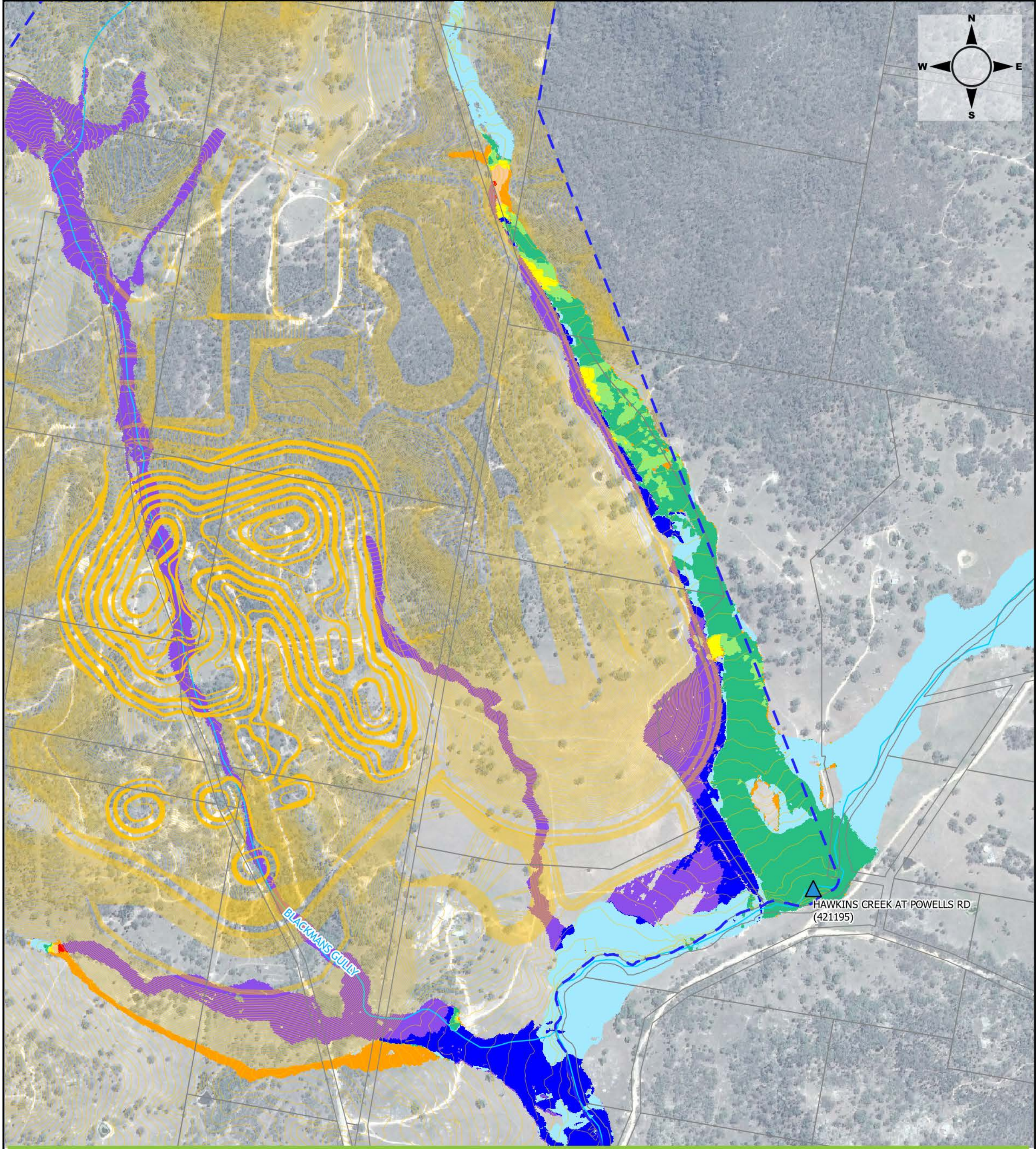
- < -1.00 m
- -1.00 m to -0.01 m
- -0.01 m to 0.01 m
- 0.01 m to 0.05 m
- 0.05 m to 0.10 m
- 0.10 m to 0.50 m
- 0.50 m to 1.00 m
- 1.00 m to 2.00 m
- 2.00 m to 3.00 m
- 3.00 m to 5.00 m
- > 5.00 m

Bowdens Silver Project

Change in Peak Water Level,
5% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak water level

- < -1.00 m
- -1.00 m to -0.01 m
- -0.01 m to 0.01 m
- 0.01 m to 0.05 m
- 0.05 m to 0.10 m
- 0.10 m to 0.50 m
- 0.50 m to 1.00 m
- 1.00 m to 2.00 m
- 2.00 m to 3.00 m
- 3.00 m to 5.00 m
- > 5.00 m

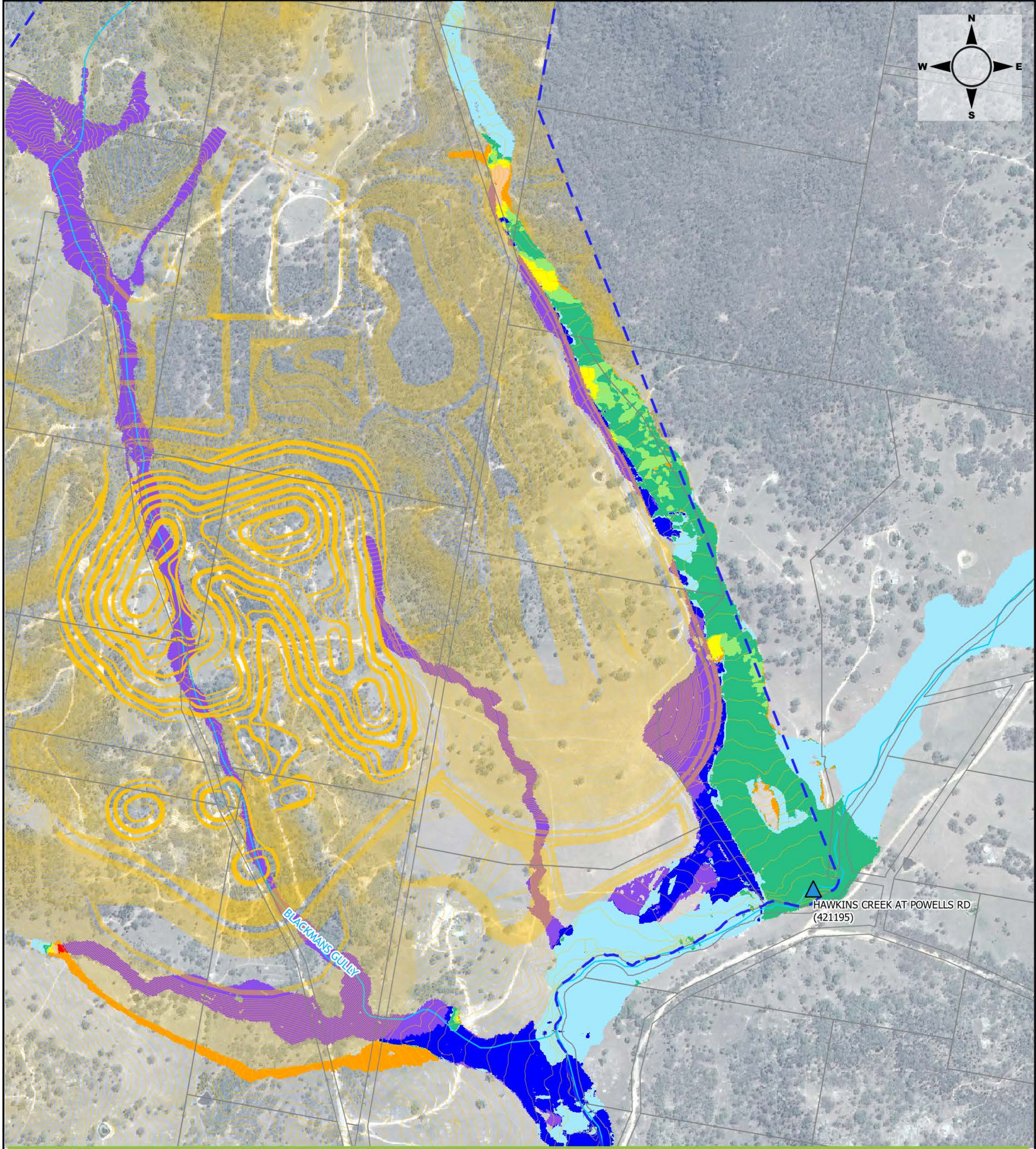
Projection: MGA Zone 55 Datum: GDA 94

Bowdens Silver Project

Change in Peak Water Level,
2% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak water level

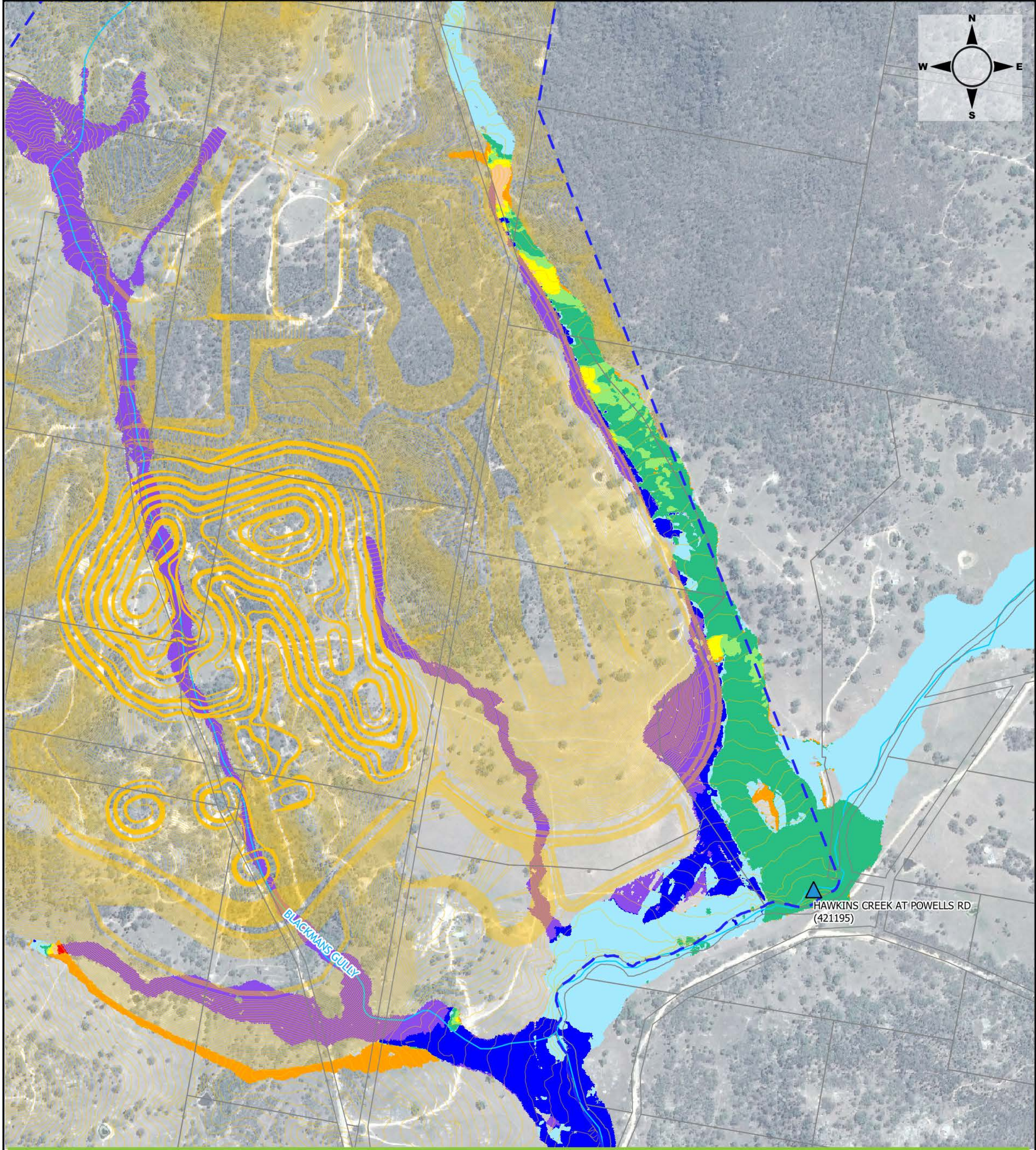
- < -1.00 m
- -1.00 m to -0.01 m
- -0.01 m to 0.01 m
- 0.01 m to 0.05 m
- 0.05 m to 0.10 m
- 0.10 m to 0.50 m
- 0.50 m to 1.00 m
- 1.00 m to 2.00 m
- 2.00 m to 3.00 m
- 3.00 m to 5.00 m
- > 5.00 m

Bowdens Silver Project

Change in Peak Water Level,
1% AEP, WRE Stage 7

0 200 400 600 m

wrm
water+environment



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak water level

- < -1.00 m
- -1.00 m to -0.01 m
- -0.01 m to 0.01 m
- 0.01 m to 0.05 m
- 0.05 m to 0.10 m
- 0.10 m to 0.50 m
- 0.50 m to 1.00 m
- 1.00 m to 2.00 m
- 2.00 m to 3.00 m
- 3.00 m to 5.00 m
- > 5.00 m

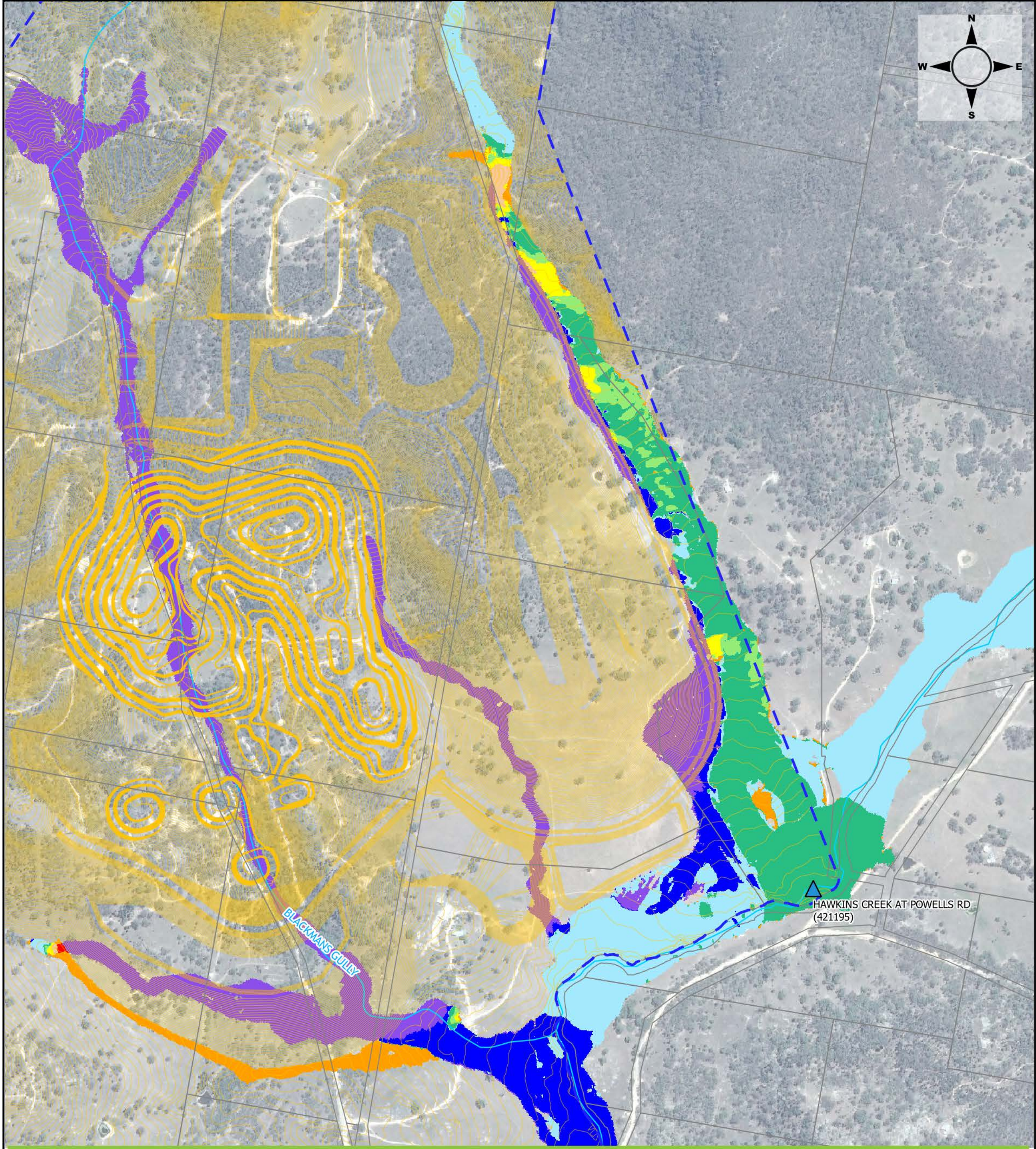
Bowdens Silver Project

Change in Peak Water Level,
0.5% AEP, WRE Stage 7

0 200 400 600 m

Projection: MGA Zone 55 Datum: GDA 94

wrm water + environment



Projection: MGA Zone 55   Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak water level

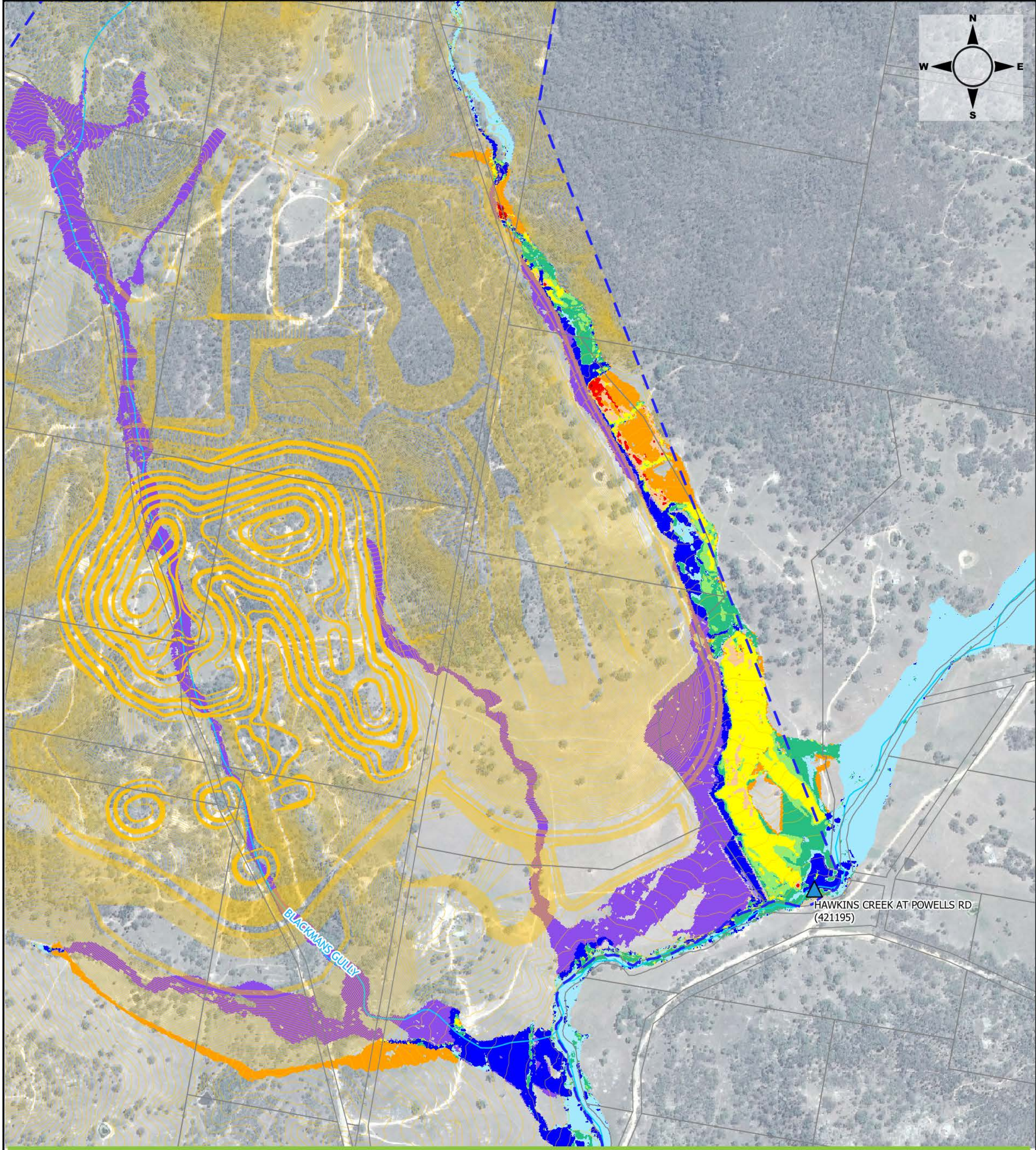
- < -1.00 m
- -1.00 m to -0.01 m
- -0.01 m to 0.01 m
- 0.01 m to 0.05 m
- 0.05 m to 0.10 m
- 0.10 m to 0.50 m
- 0.50 m to 1.00 m
- 1.00 m to 2.00 m
- 2.00 m to 3.00 m
- 3.00 m to 5.00 m
- > 5.00 m

Bowdens Silver Project

Change in Peak Water Level,
0.2% AEP, WRE Stage 7

0 200 400 600 m

wrm
water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- ▲ Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak velocity

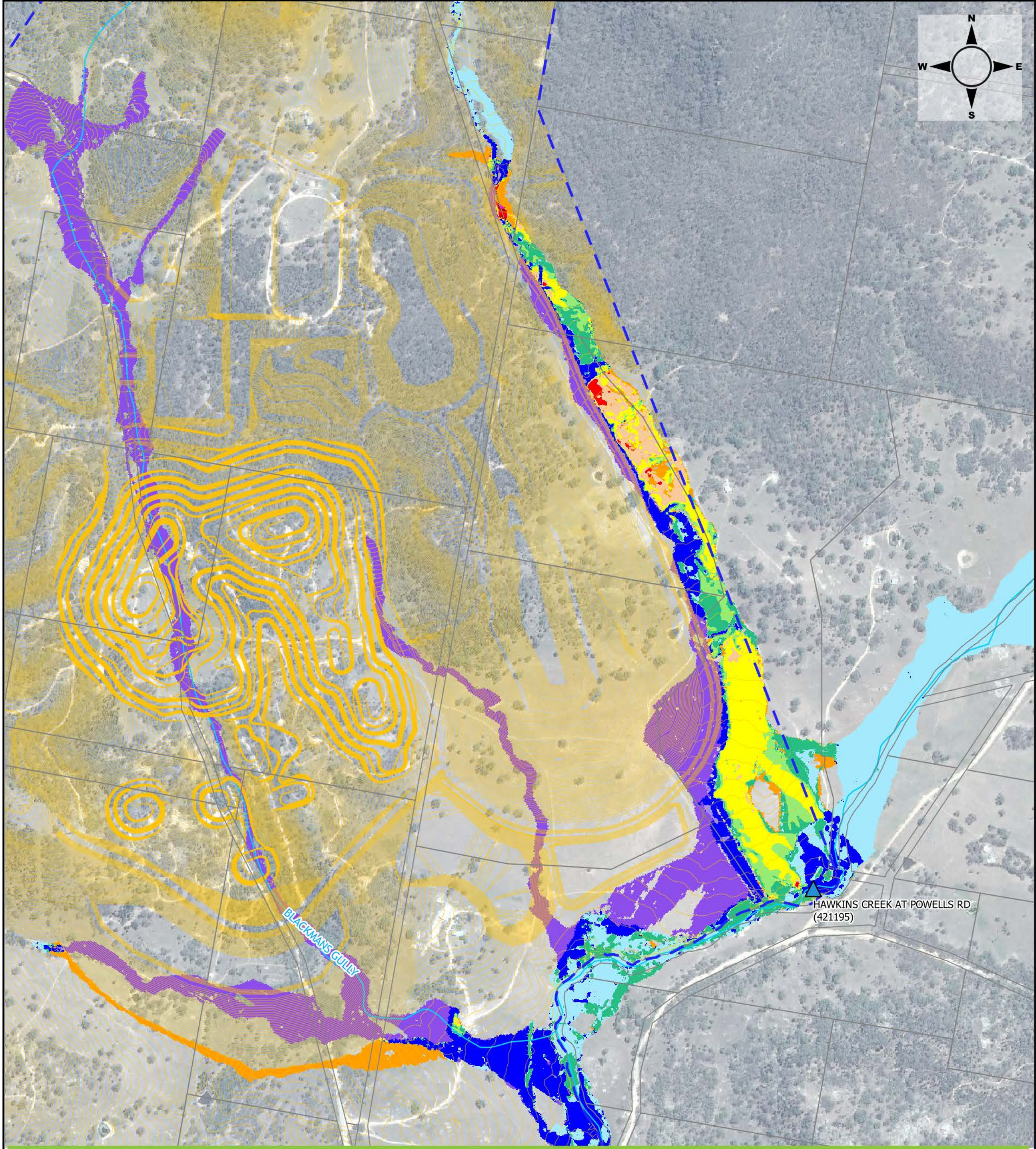
- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s

Bowdens Silver Project

Change in Peak Velocity,
10% AEP, WRE Stage 7

0 200 400 600 m

wrm
water + environment



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak velocity

- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s

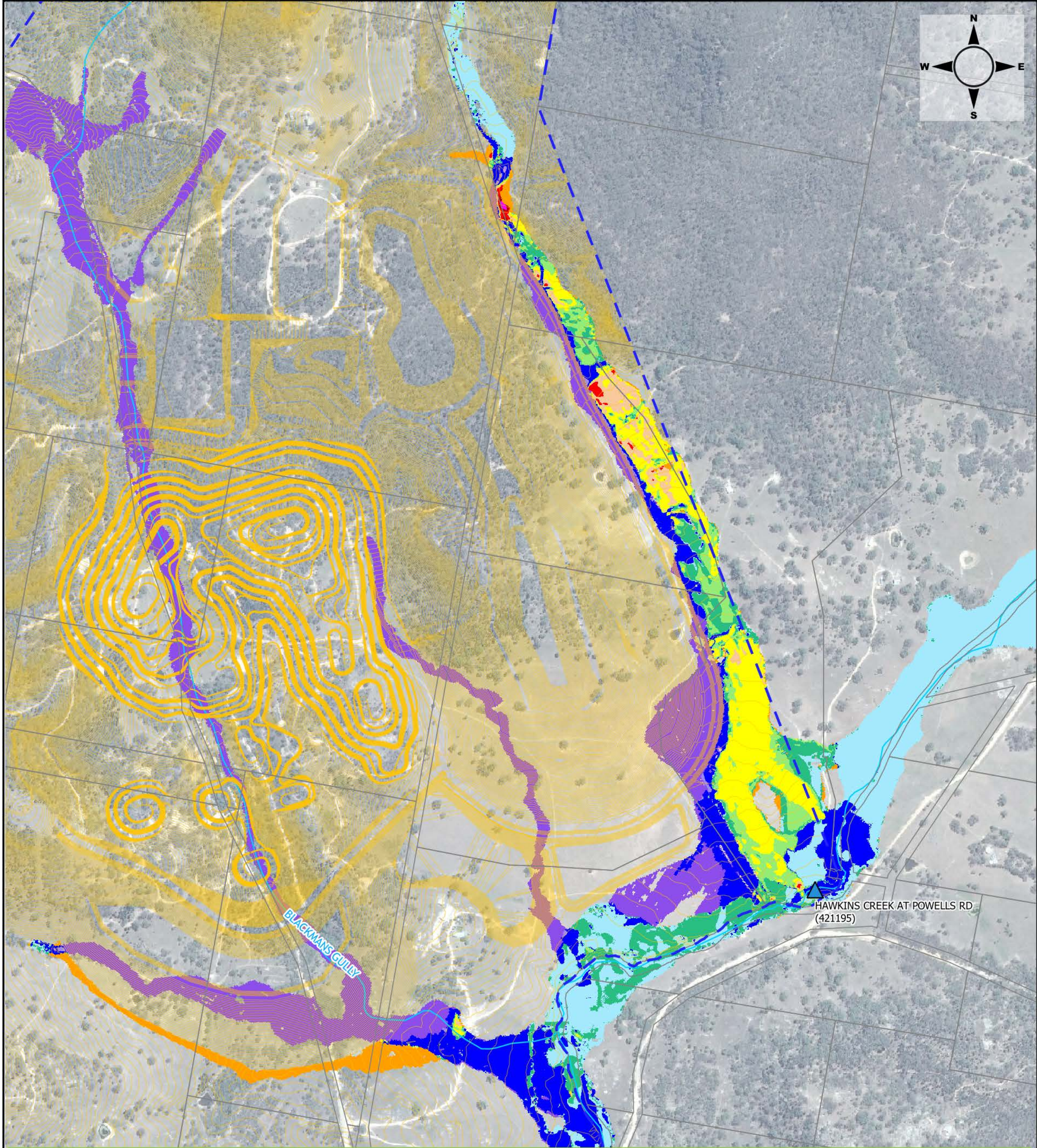
Bowdens Silver Project

Change in Peak Velocity,
5% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak velocity

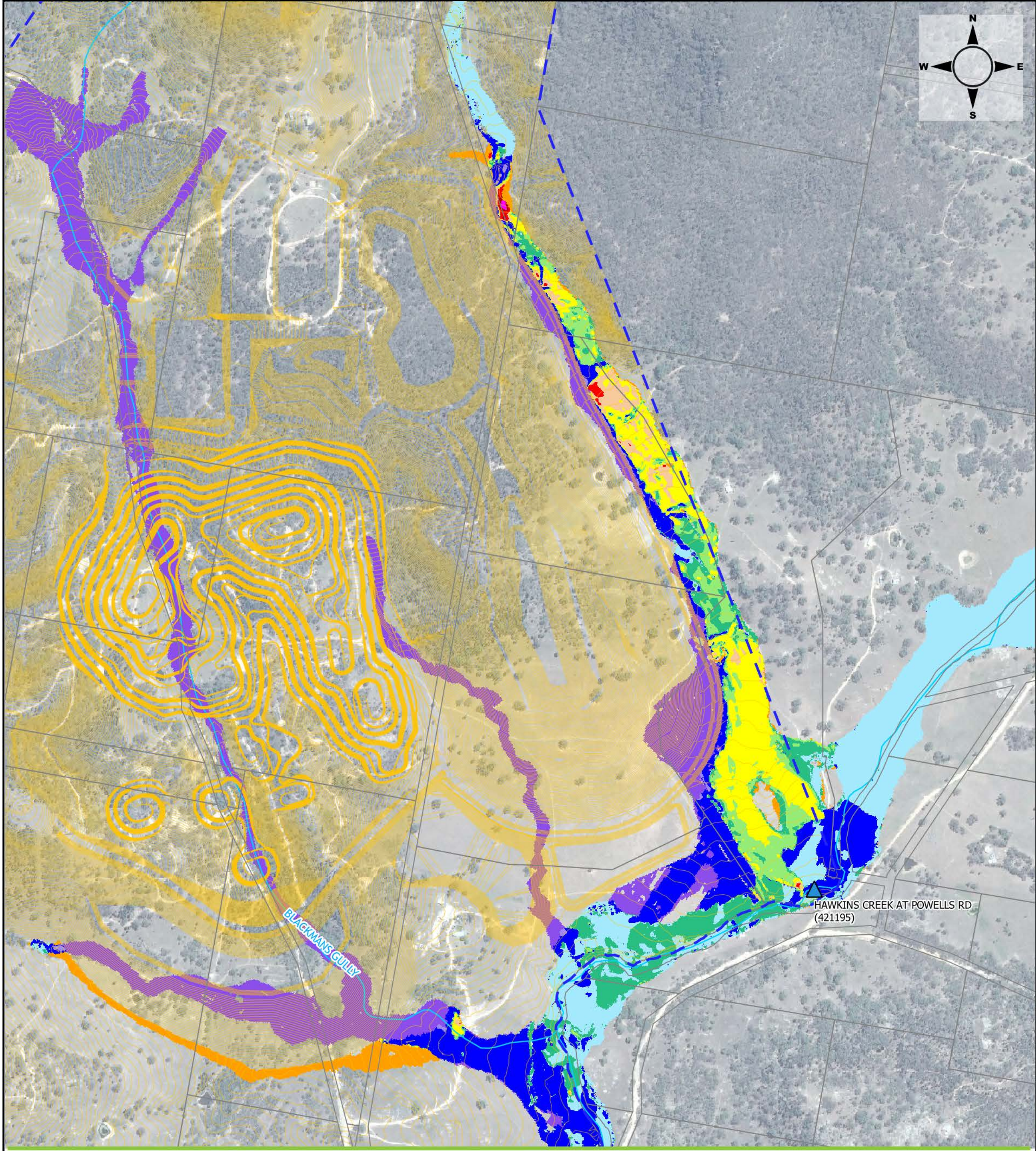
- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s

Bowdens Silver Project

Change in Peak Velocity,
2% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak velocity

- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s

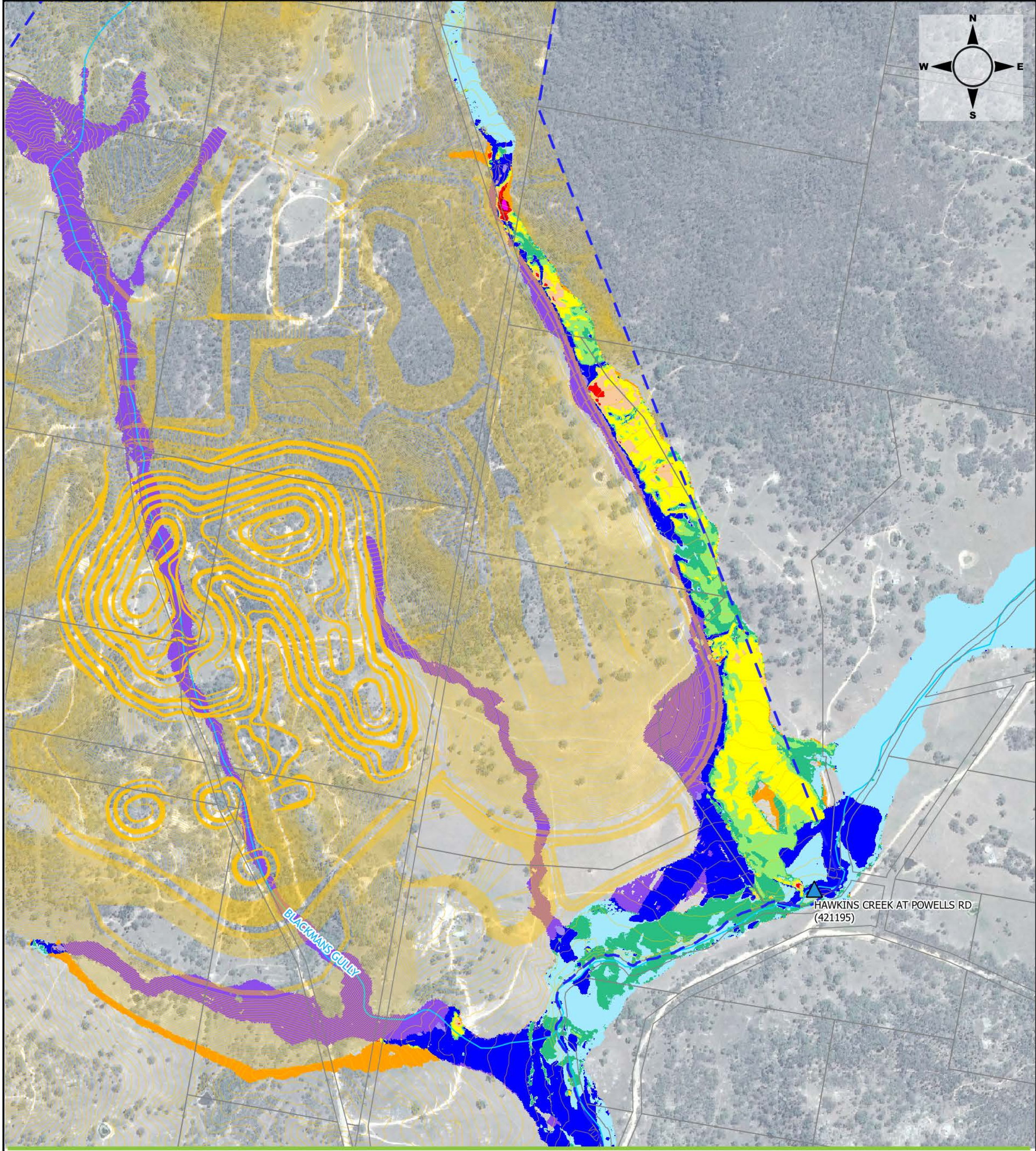
Bowdens Silver Project

Change in Peak Velocity,
1% AEP, WRE Stage 7

0 200 400 600 m

wrm
water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak velocity

- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s

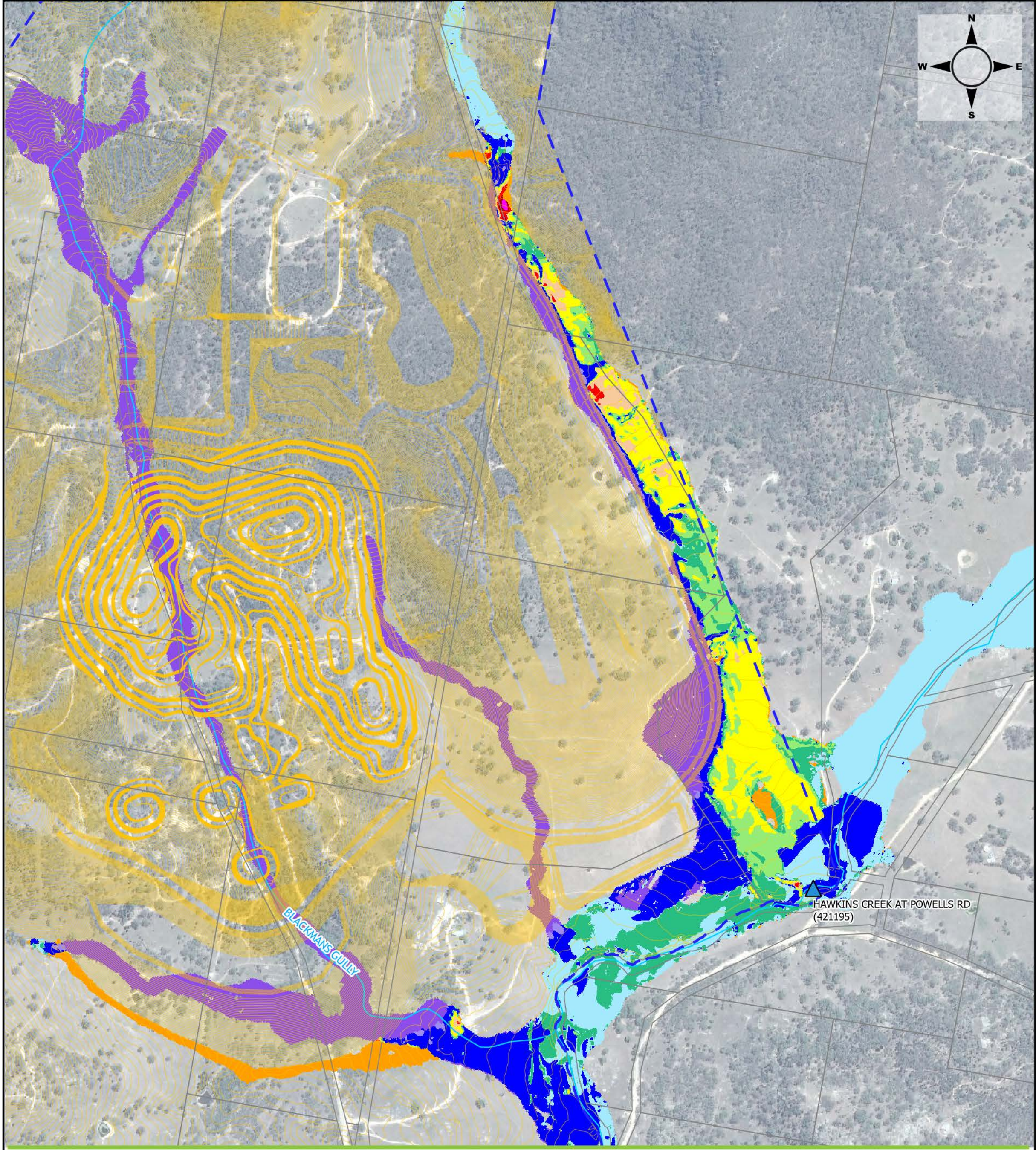
Bowdens Silver Project

Change in Peak Velocity, 0.5% AEP, WRE Stage 7

0 200 400 600 m

wrm water+environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak velocity

- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s

Bowdens Silver Project

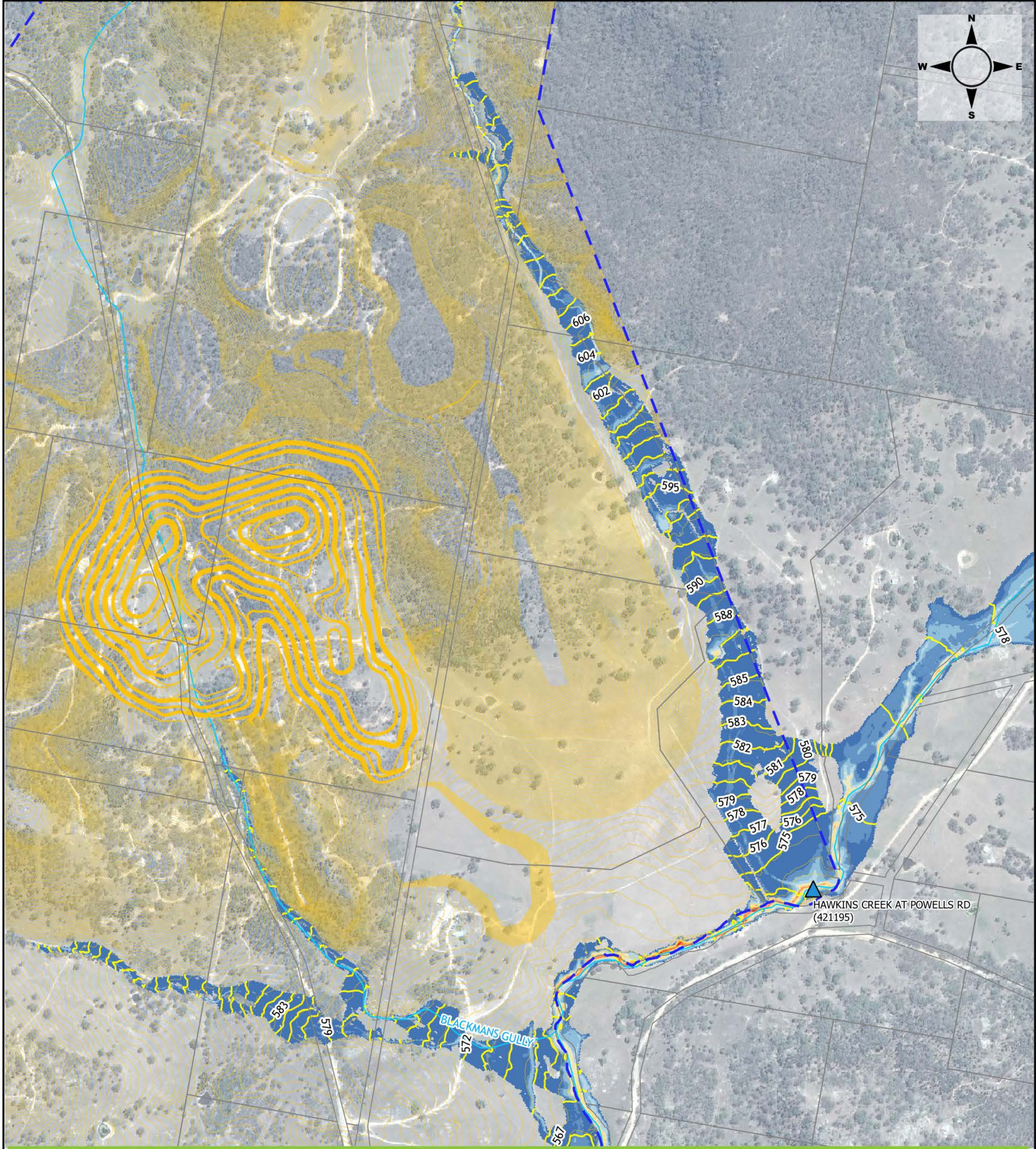
Change in Peak Velocity, 0.2% AEP, WRE Stage 7

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

Appendix E - Flood maps - Final landform scenario



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

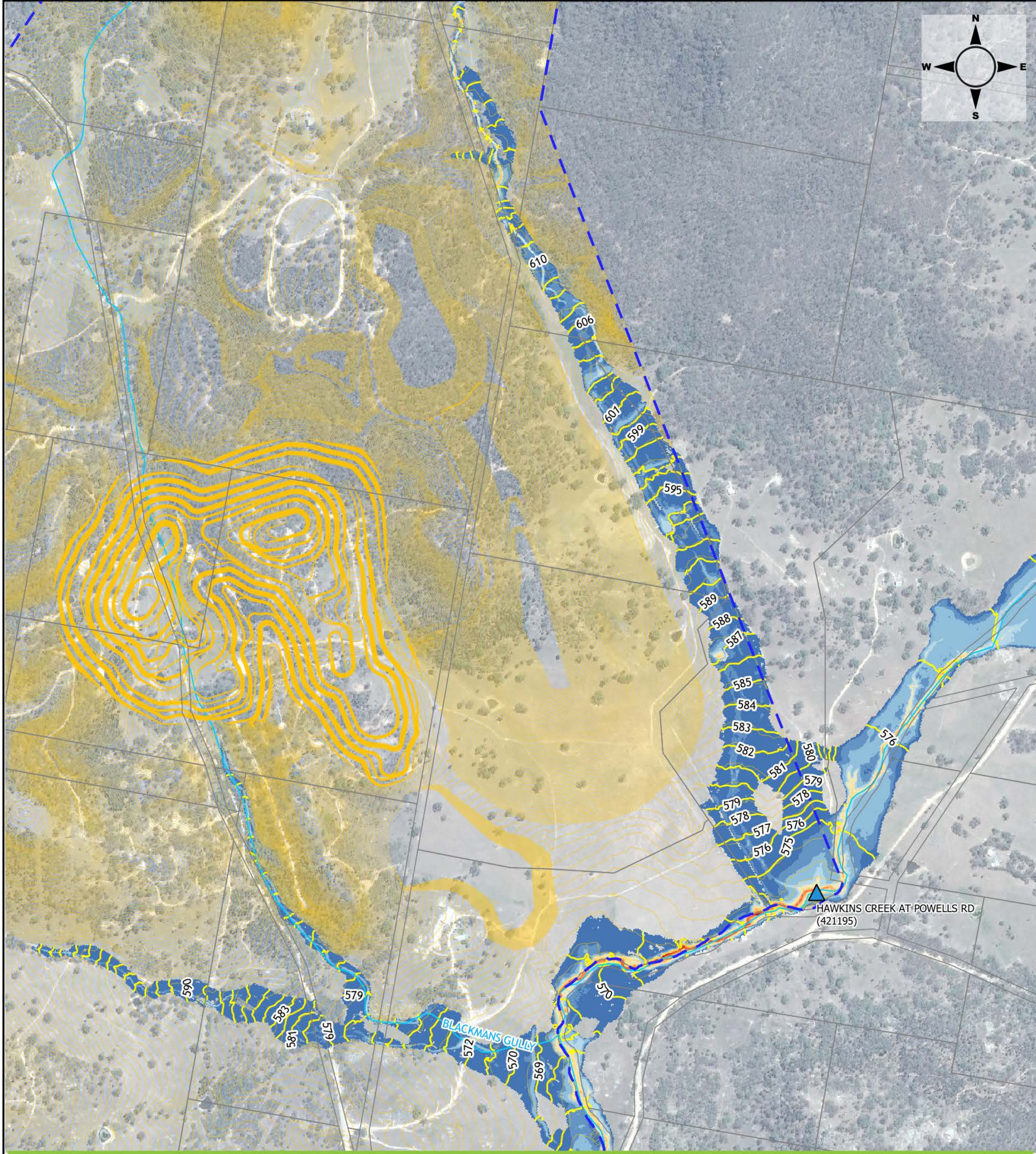
Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), 10% AEP, Final Landform

0 200 400 600 m

wrm
water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

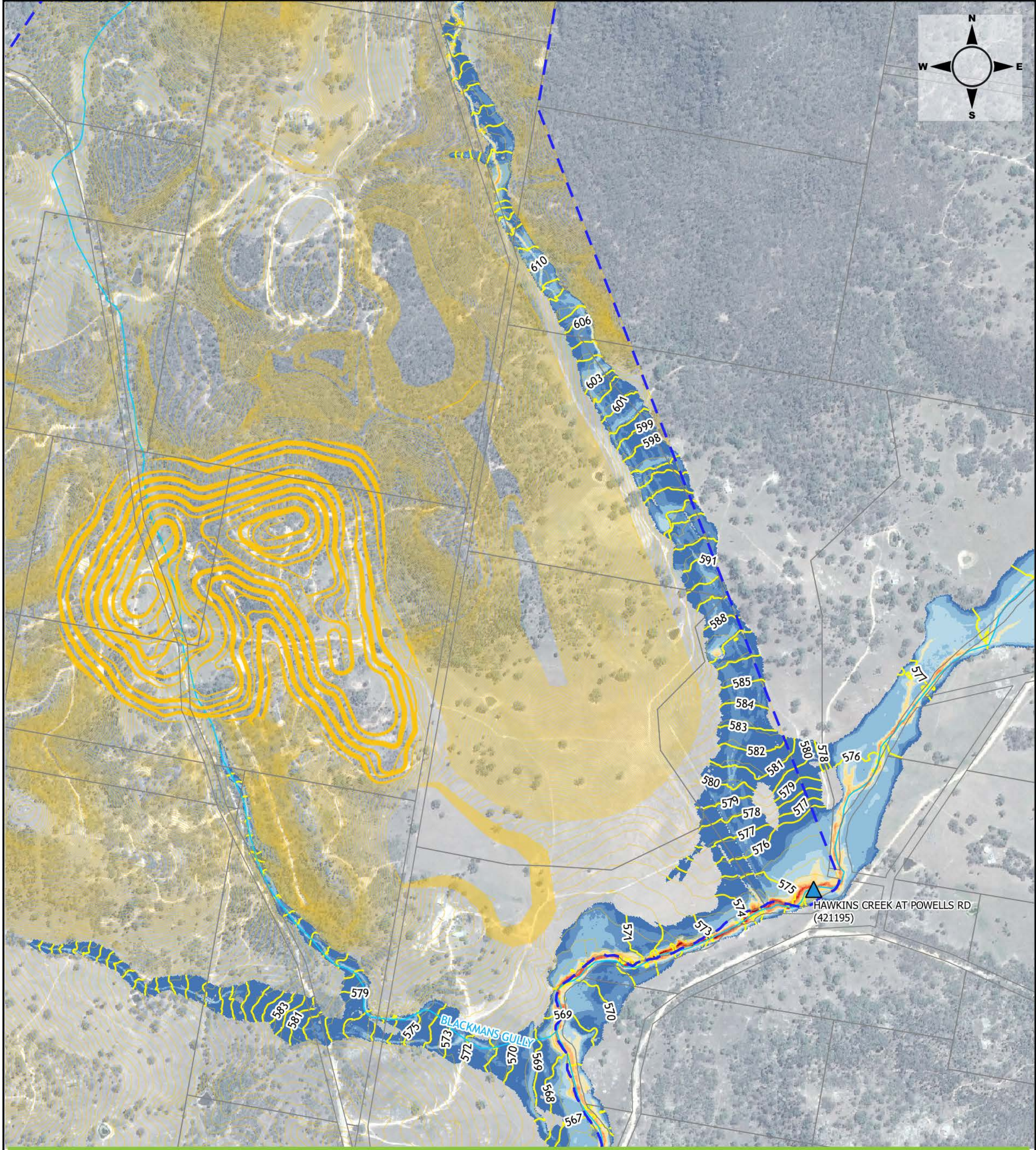
Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), 5% AEP, Final Landform

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

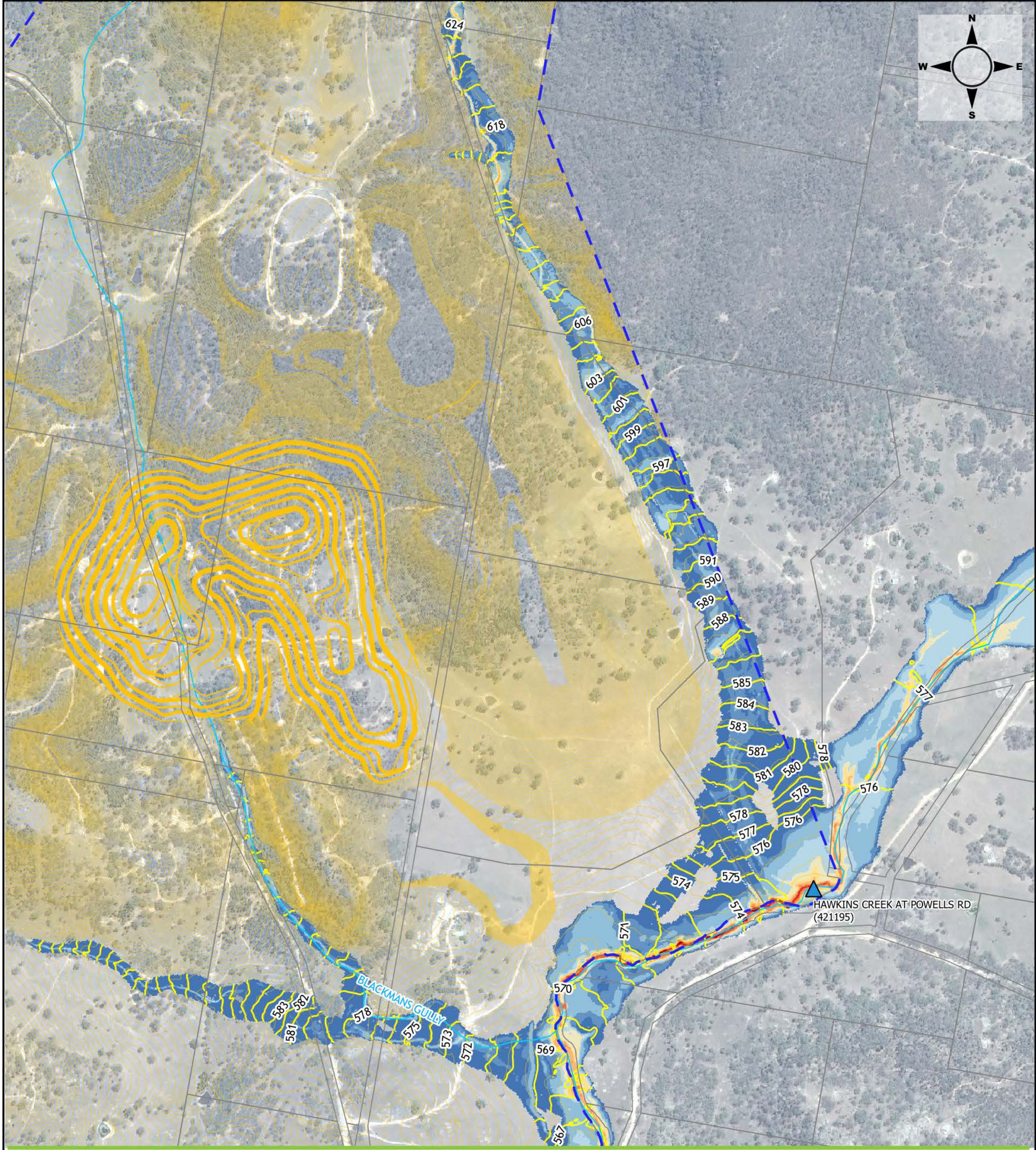
Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), 2% AEP, Final Landform

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

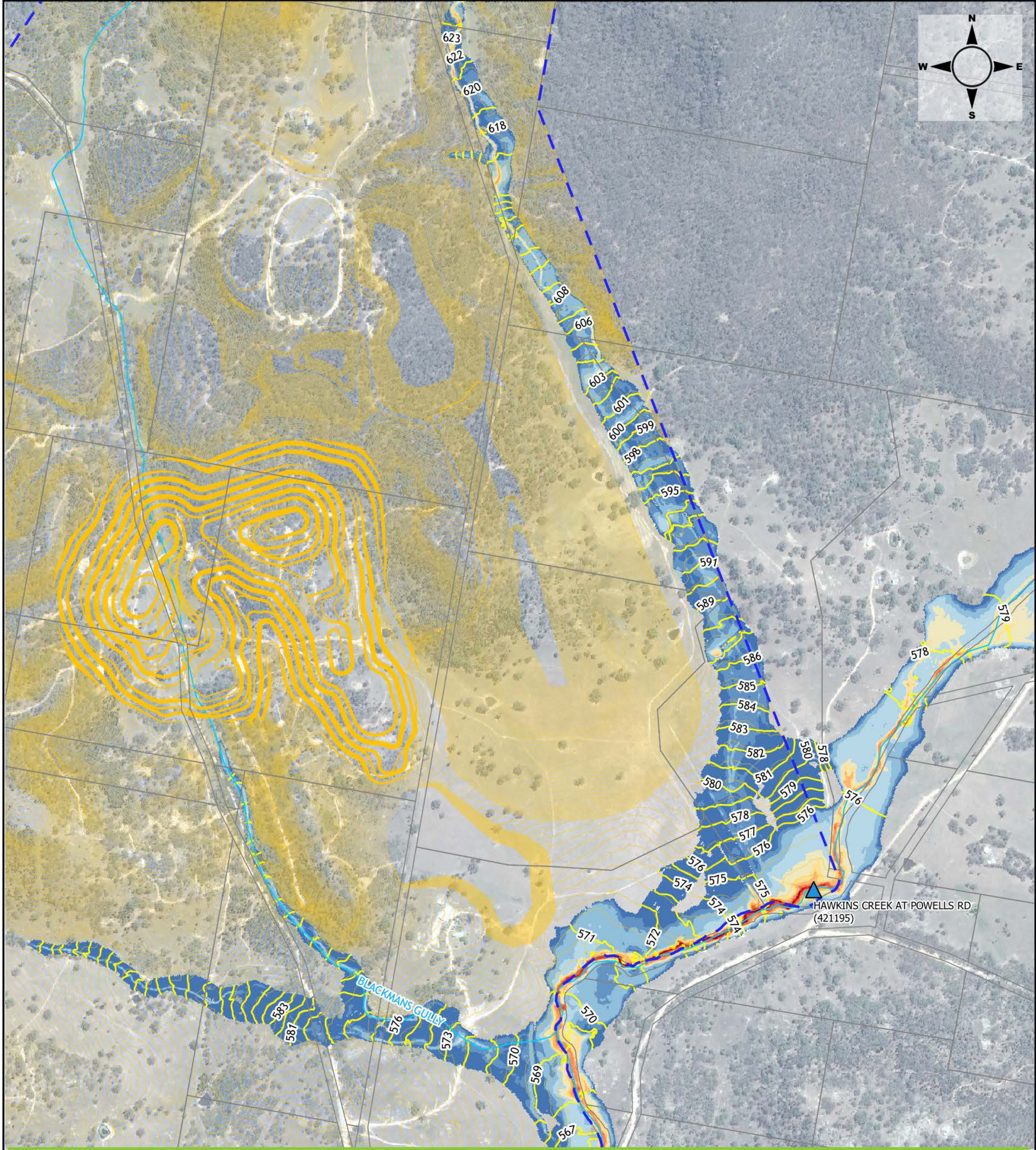
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), 1% AEP, Final Landform

0 200 400 600 m

wrm water + environment



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

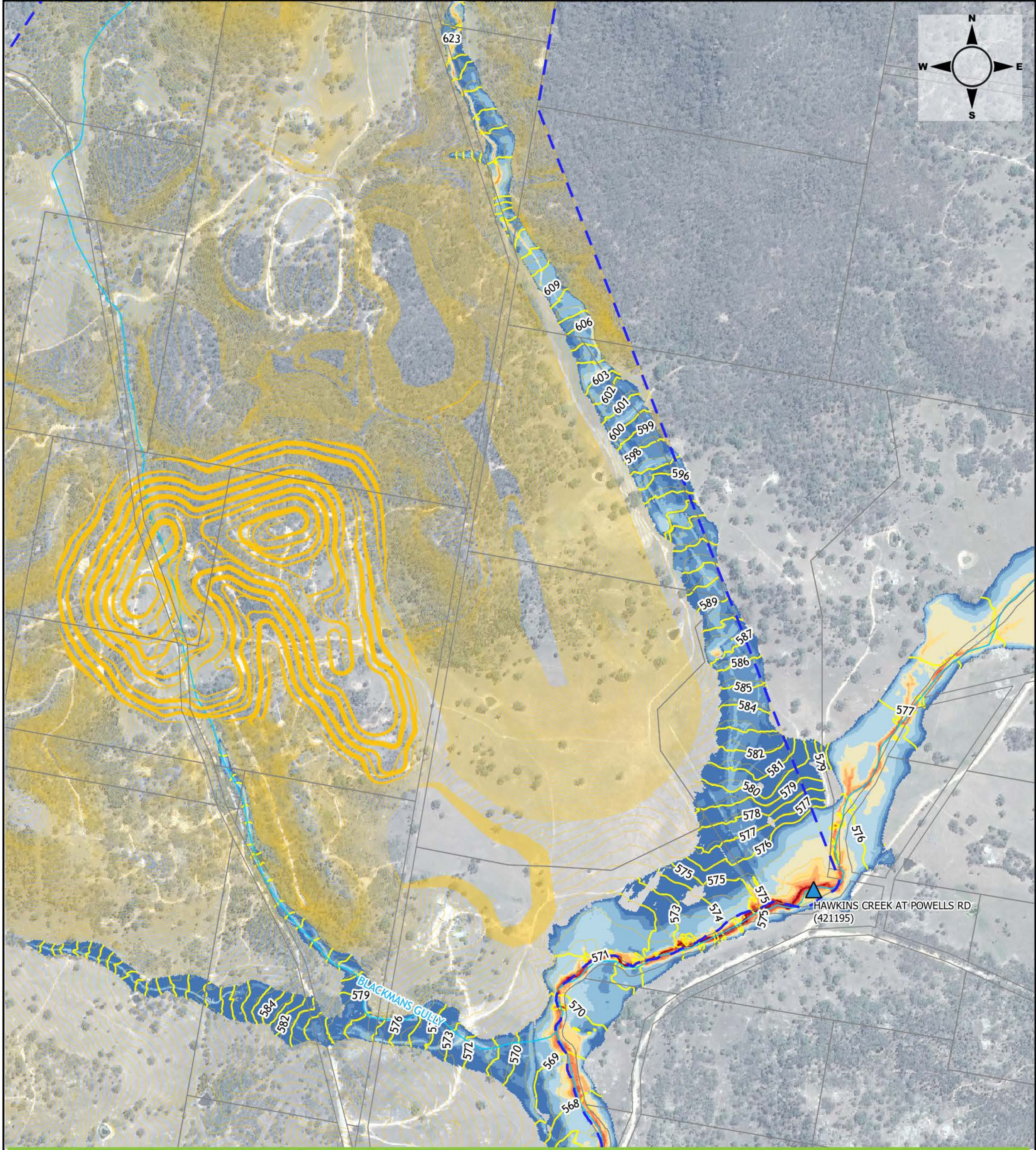
Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), 0.5% AEP, Final Landform

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

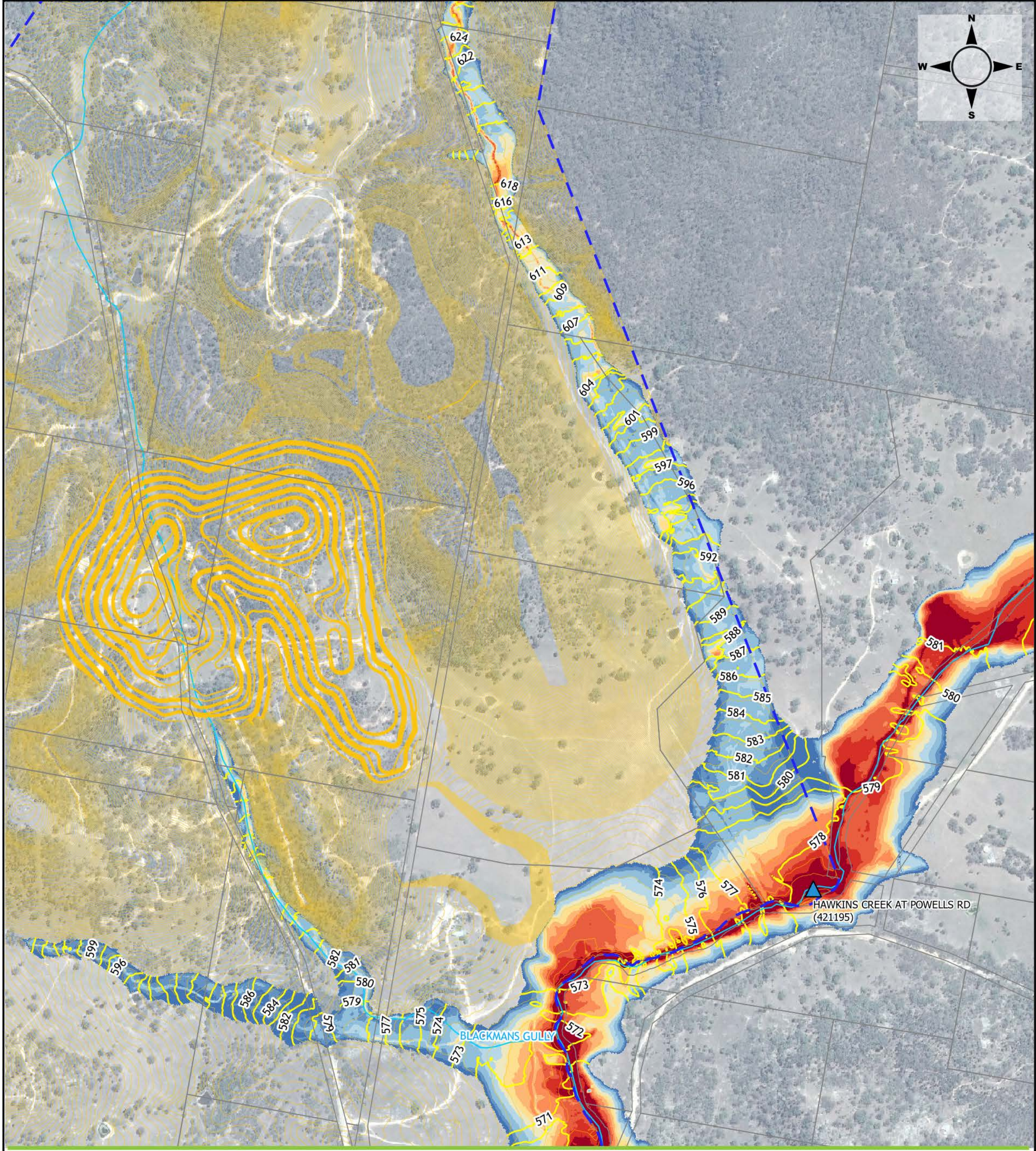
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), 0.2% AEP, Final Landform

0 200 400 600 m

wrm water + environment



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

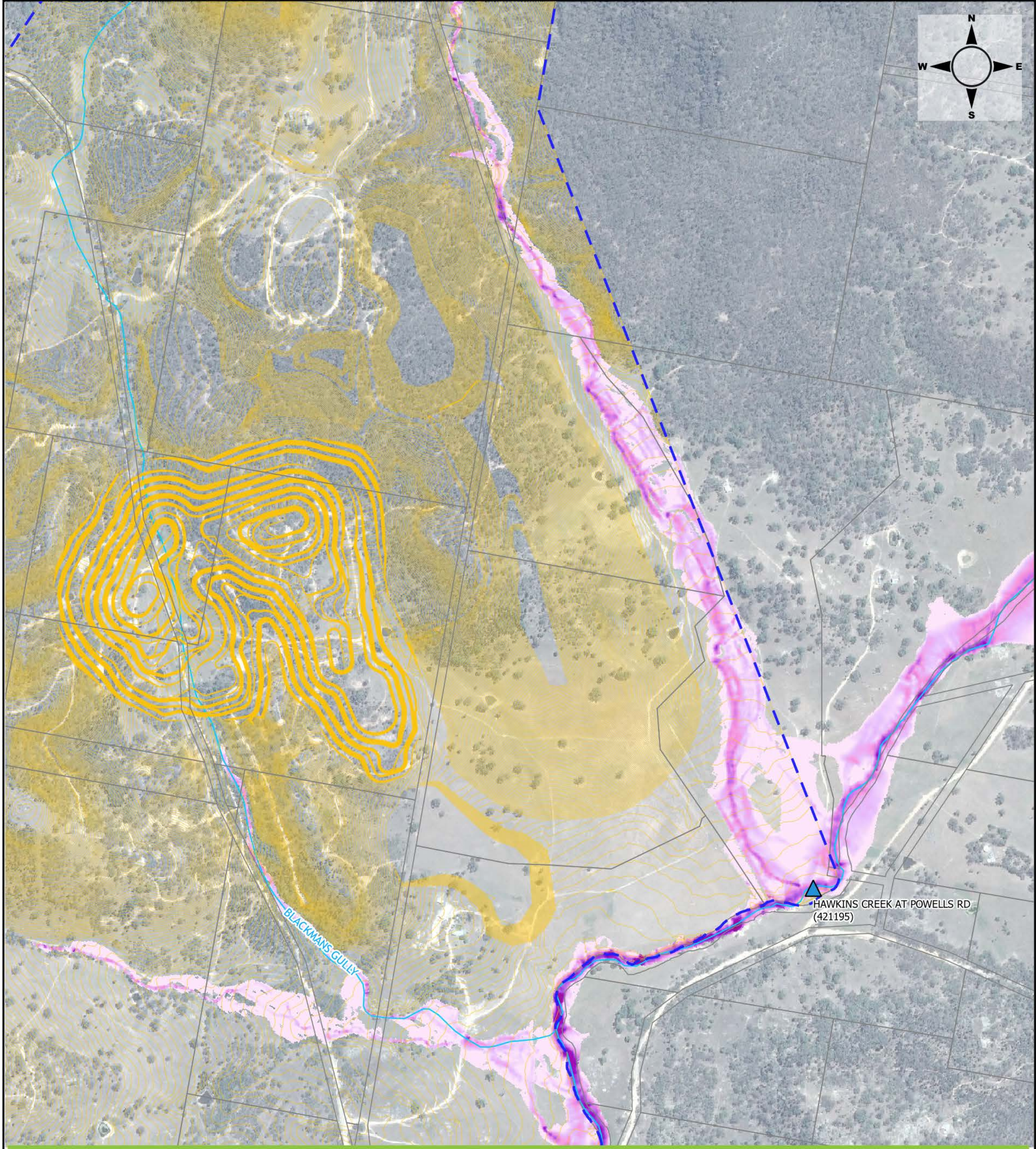
Bowdens Silver Project

Predicted Flood Extents & Depths (Developed Condition), PMF, Final Landform

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

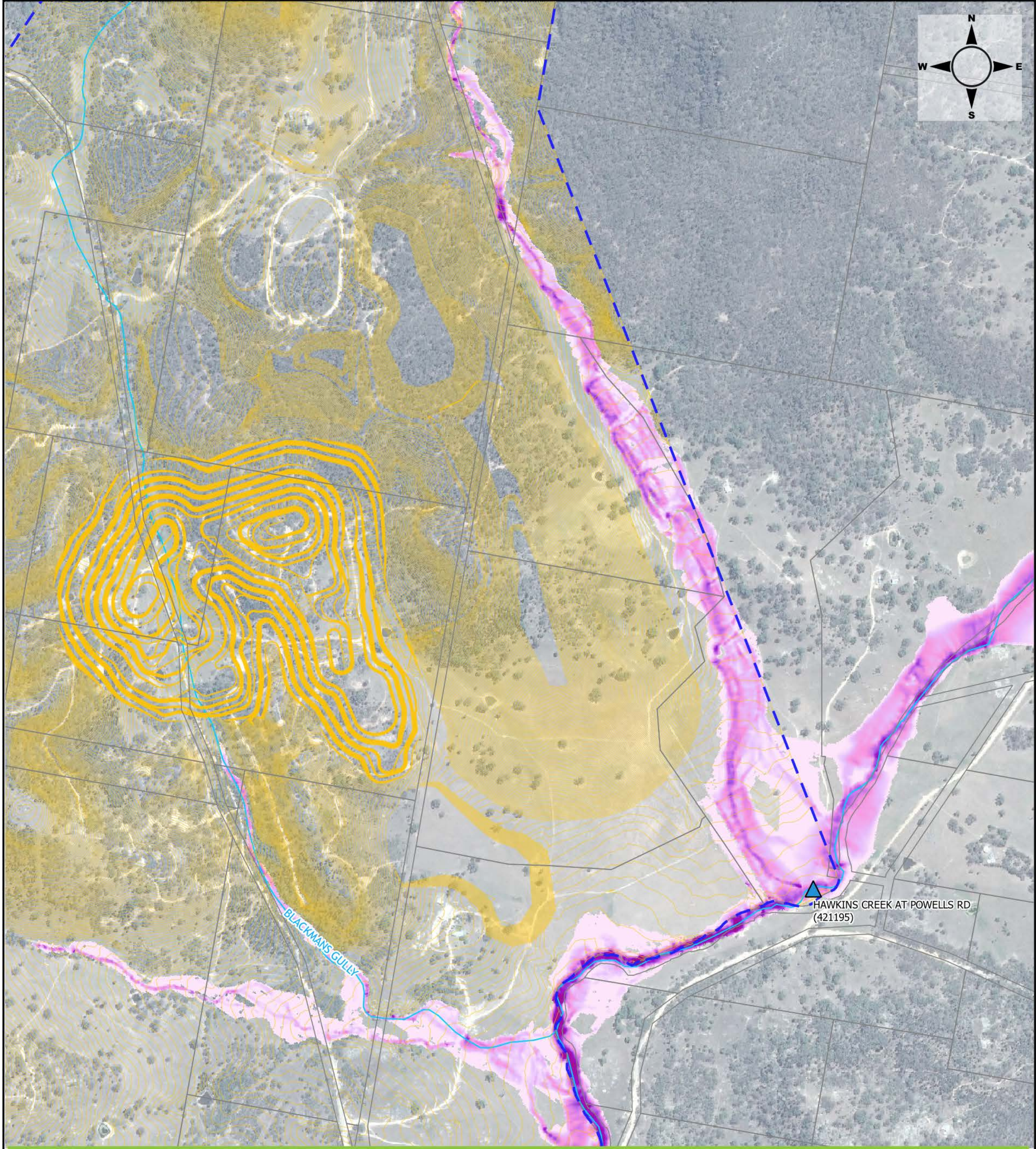
Bowdens Silver Project

Predicted Flood Velocity (Developed Condition), 10% AEP, Final Landform

0 200 400 600 m

wrm
water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

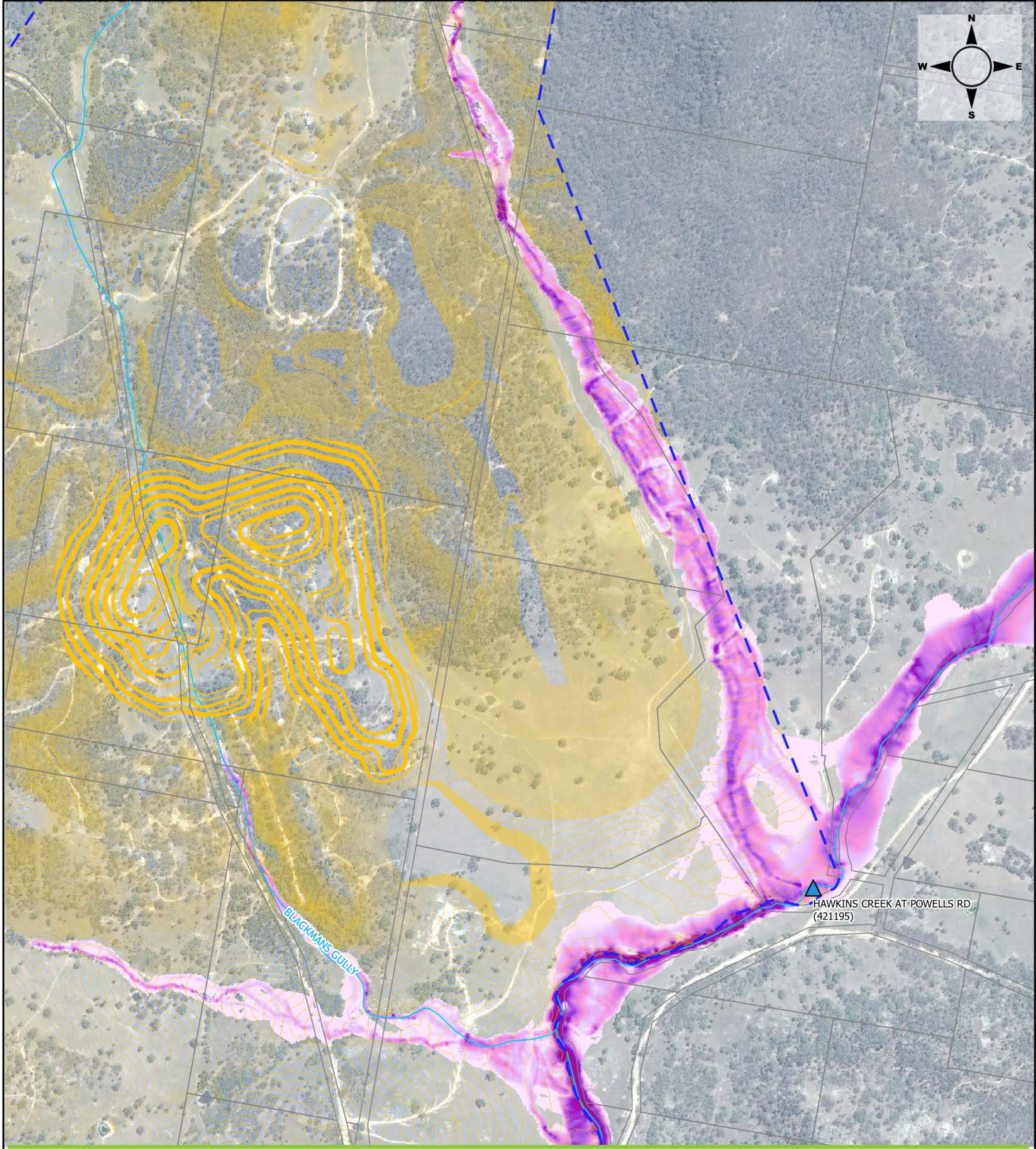
Bowdens Silver Project

Predicted Flood Velocity (Developed Condition), 5% AEP, Final Landform

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Velocity

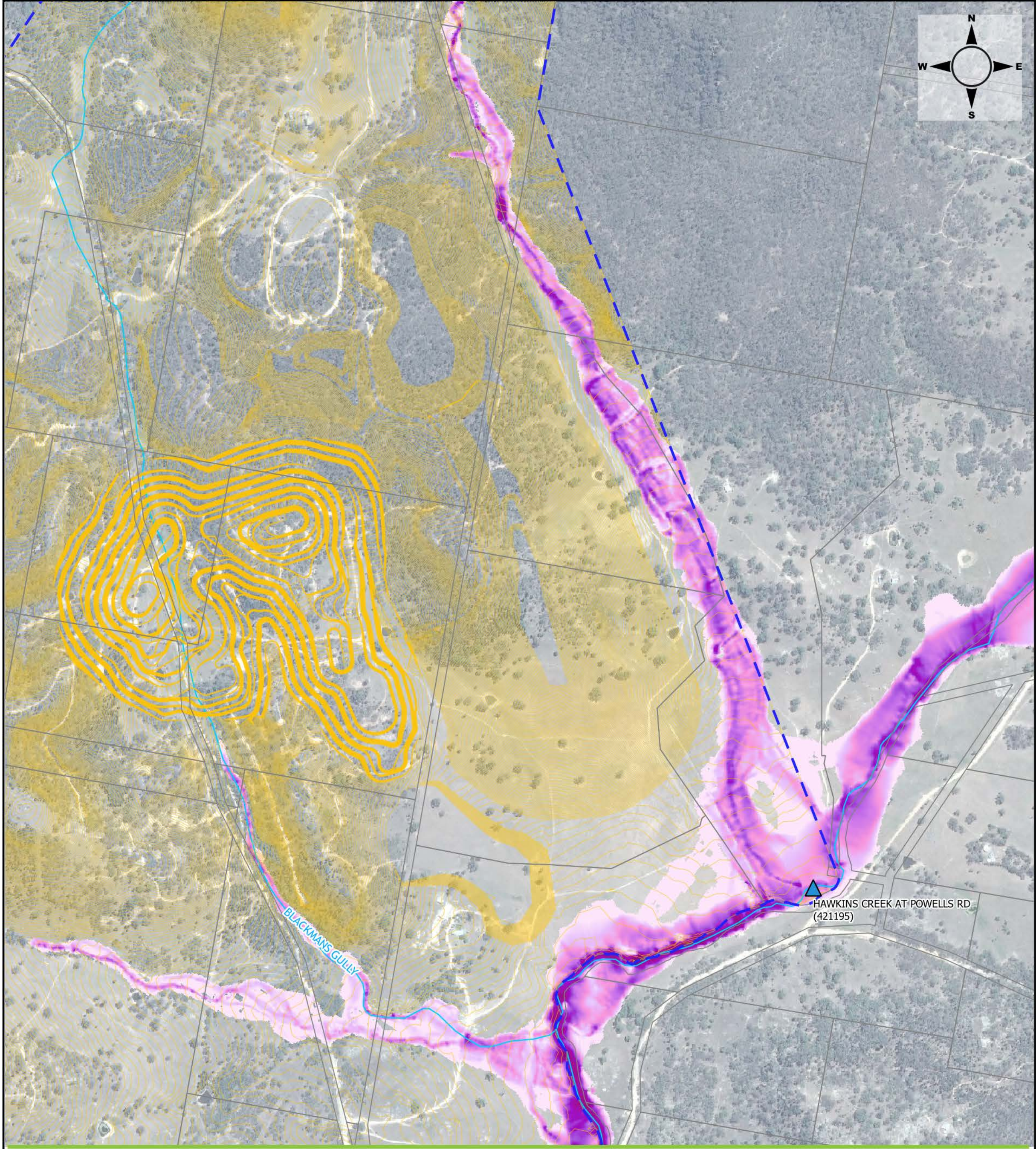
- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

Bowdens Silver Project

Predicted Flood Velocity (Developed Condition), 2% AEP, Final Landform

0 200 400 600 m

wrm water + environment



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

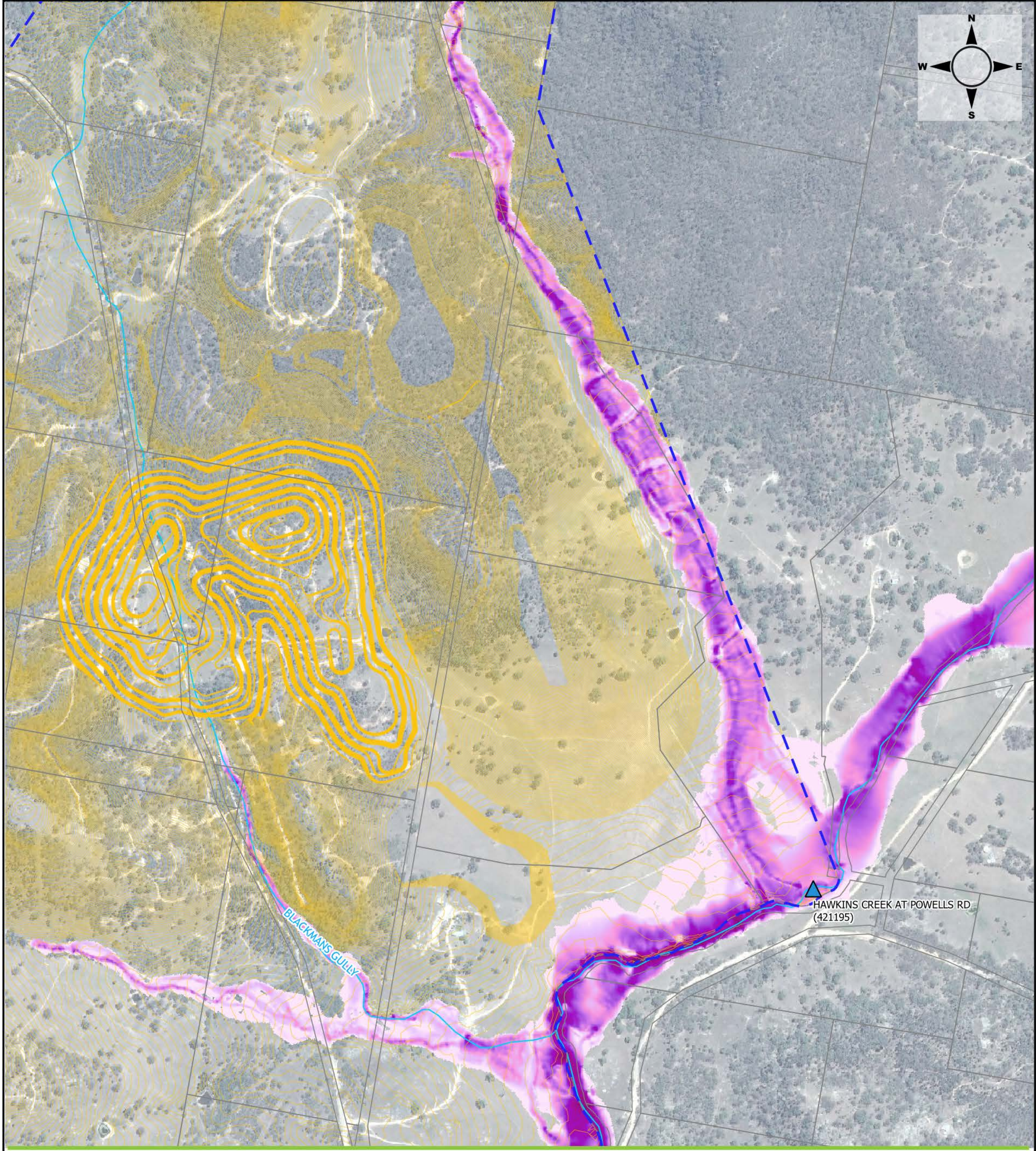
Bowdens Silver Project

Predicted Flood Velocity (Developed Condition), 1% AEP, Final Landform

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

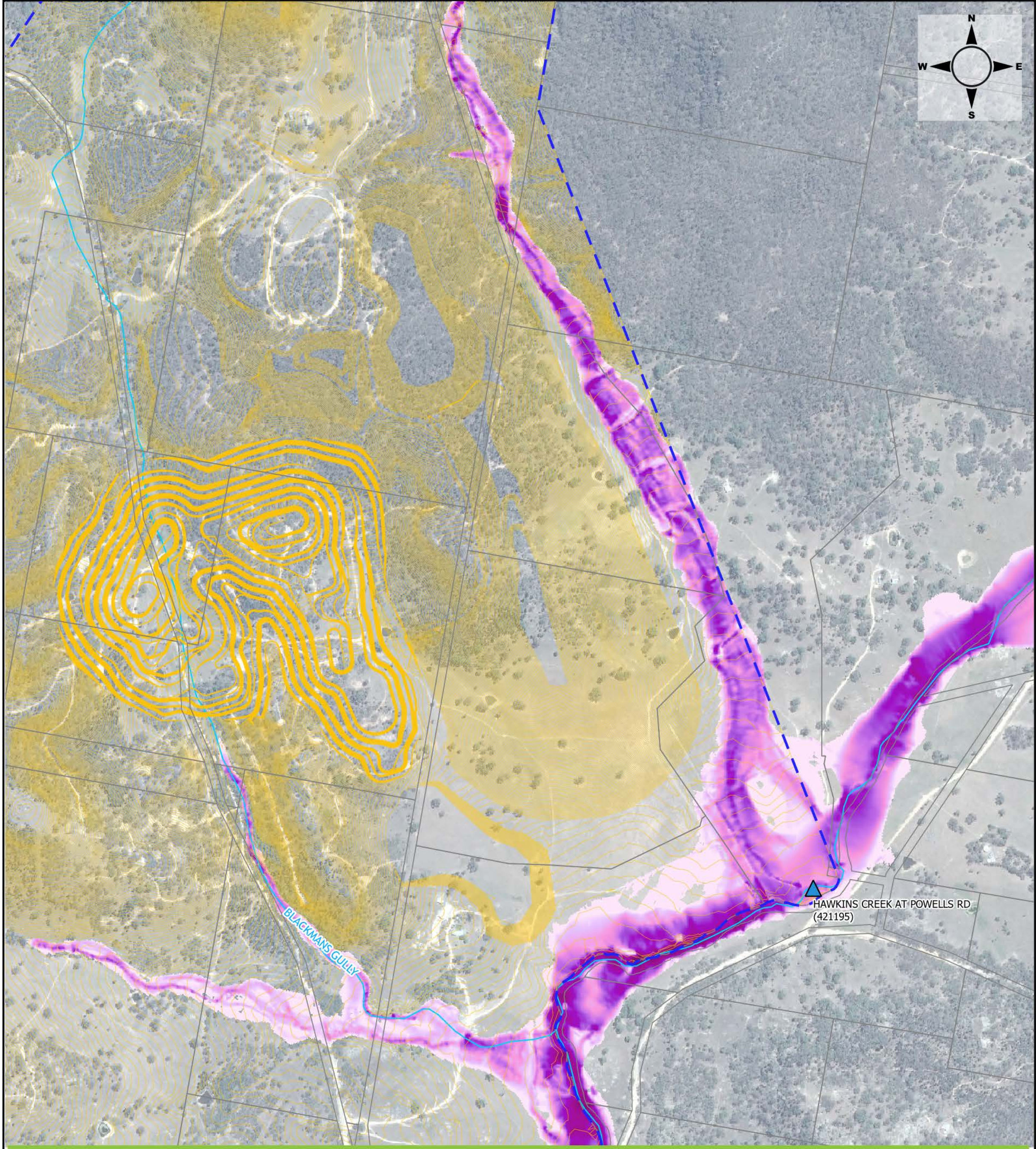
Projection: MGA Zone 55 Datum: GDA 94

Bowdens Silver Project

Predicted Flood Velocity (Developed Condition), 0.5% AEP, Final Landform

0 200 400 600 m

wrm water + environment



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

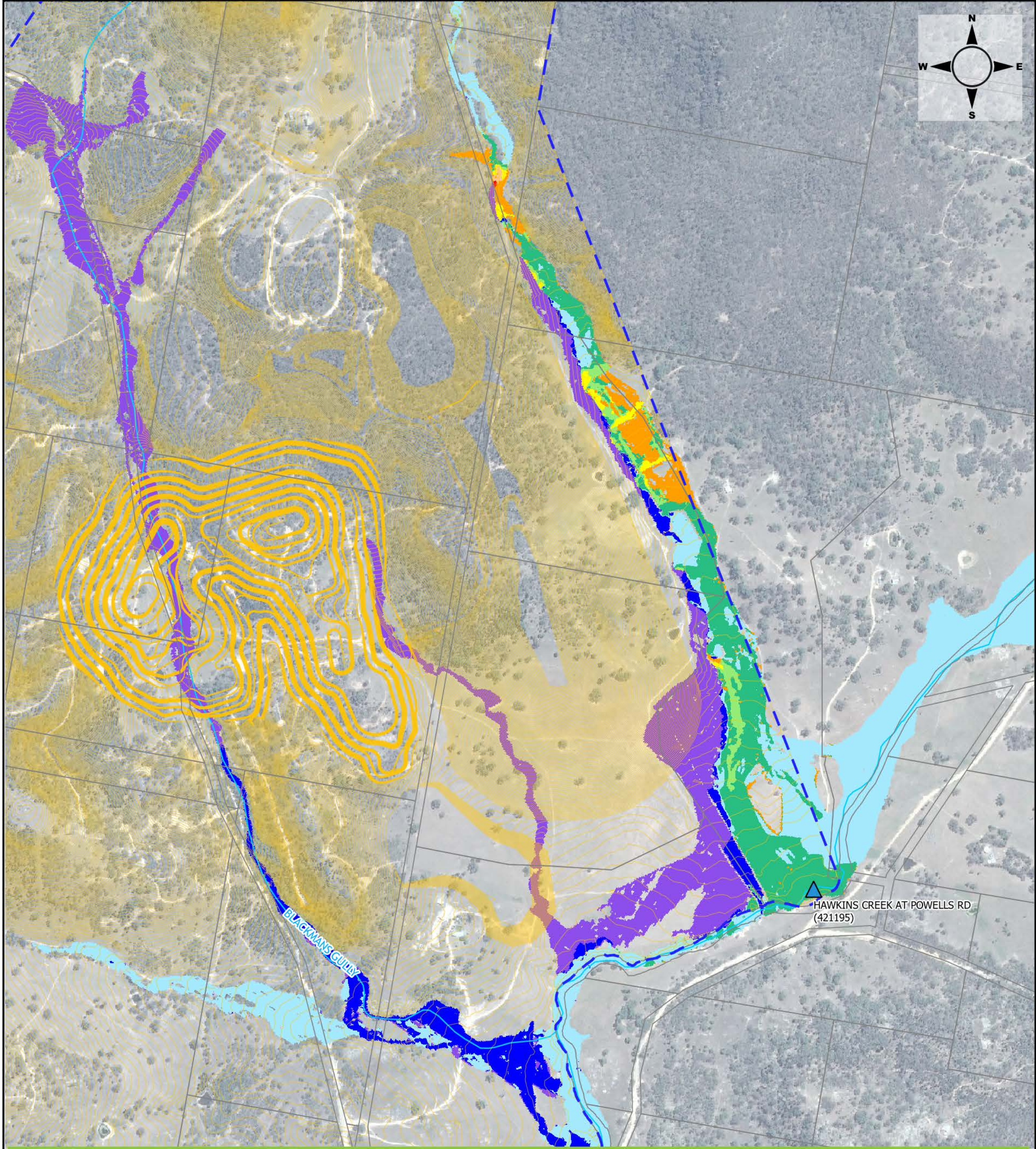
Bowdens Silver Project

Predicted Flood Velocity (Developed Condition),
0.2% AEP, Final Landform

0 200 400 600 m

Projection: MGA Zone 55 Datum: GDA 94

wrm
water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak water level

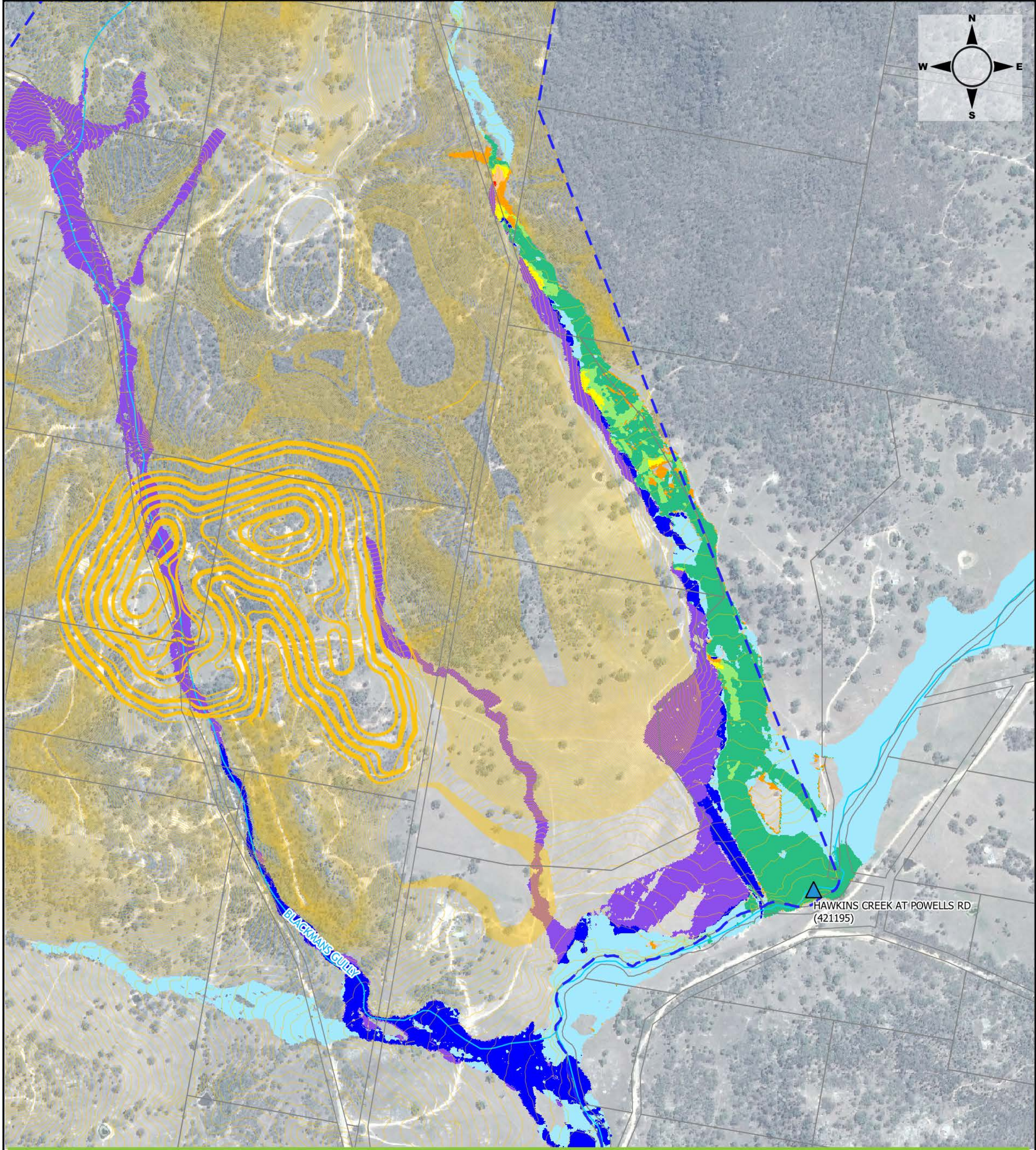
- < -1.00 m
- -1.00 m to -0.01 m
- -0.01 m to 0.01 m
- 0.01 m to 0.05 m
- 0.05 m to 0.10 m
- 0.10 m to 0.50 m
- 0.50 m to 1.00 m
- 1.00 m to 2.00 m
- 2.00 m to 3.00 m
- 3.00 m to 5.00 m
- > 5.00 m

Bowdens Silver Project

Change in Peak Water Level, 10% AEP, Final Landform

0 200 400 600 m

wrm water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak water level

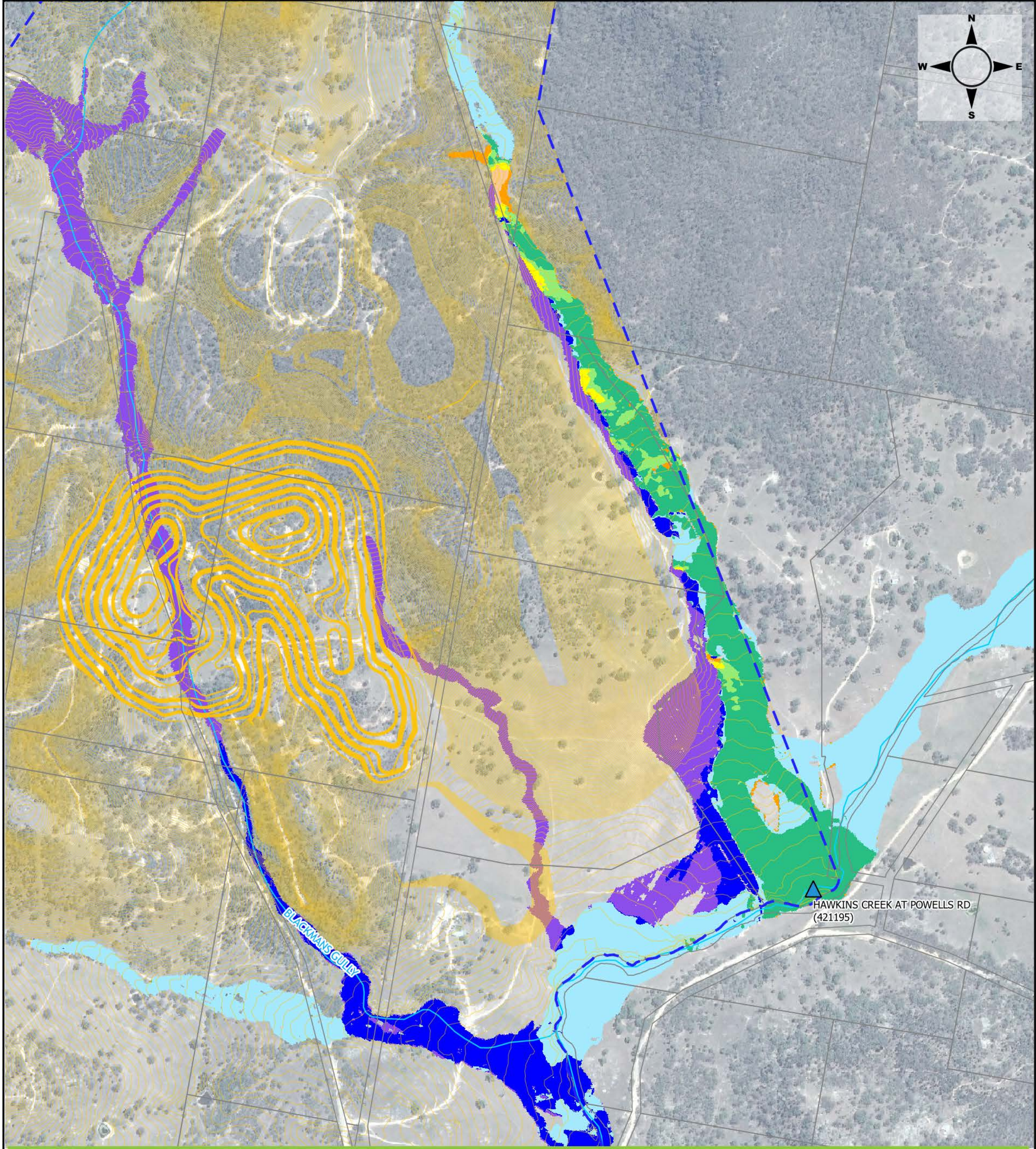
- < -1.00 m
- -1.00 m to -0.01 m
- -0.01 m to 0.01 m
- 0.01 m to 0.05 m
- 0.05 m to 0.10 m
- 0.10 m to 0.50 m
- 0.50 m to 1.00 m
- 1.00 m to 2.00 m
- 2.00 m to 3.00 m
- 3.00 m to 5.00 m
- > 5.00 m

Bowdens Silver Project

Change in Peak Water Level, 5% AEP, Final Landform

0 200 400 600 m

wrm water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak water level

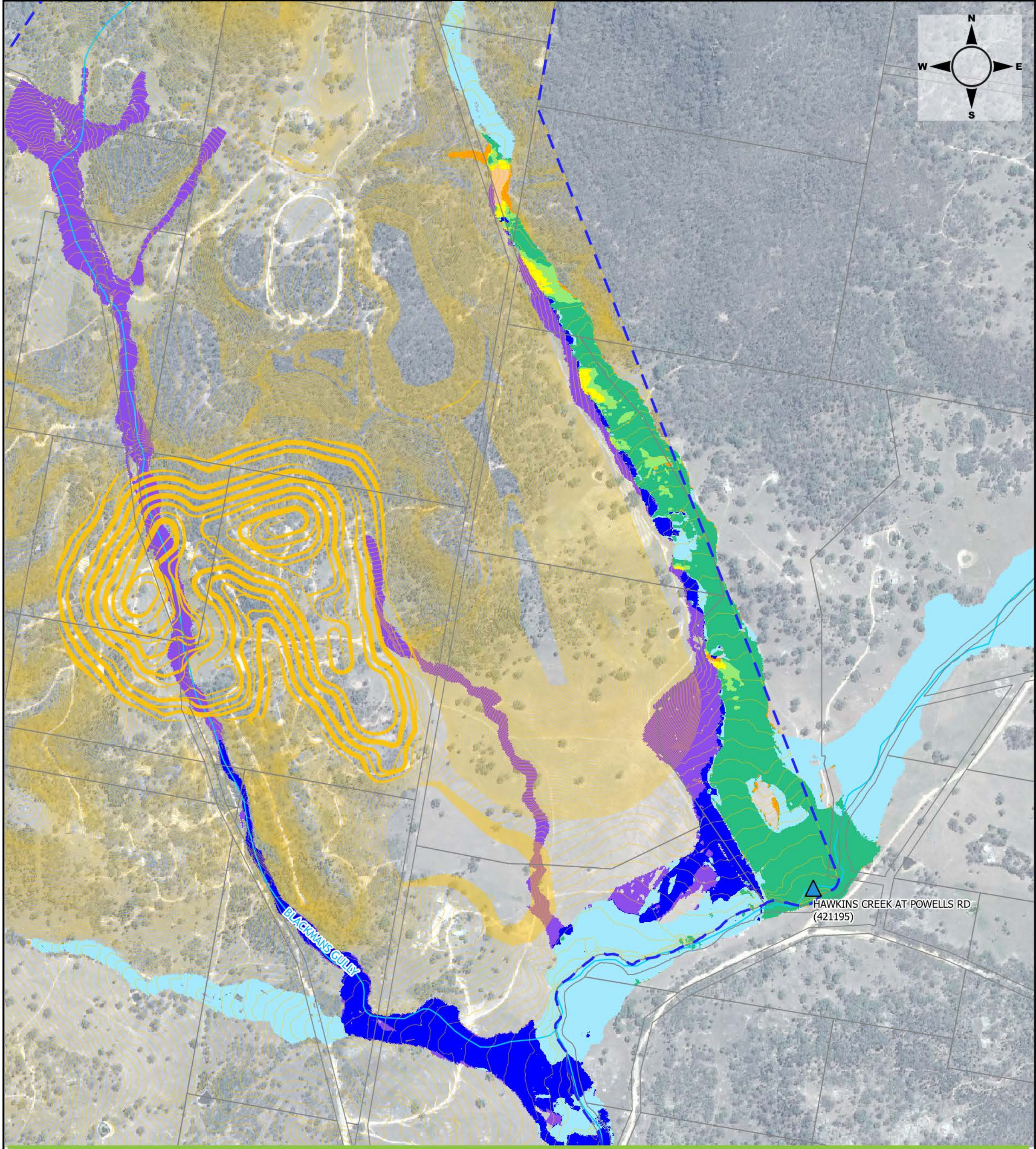
- < -1.00 m
- -1.00 m to -0.01 m
- -0.01 m to 0.01 m
- 0.01 m to 0.05 m
- 0.05 m to 0.10 m
- 0.10 m to 0.50 m
- 0.50 m to 1.00 m
- 1.00 m to 2.00 m
- 2.00 m to 3.00 m
- 3.00 m to 5.00 m
- > 5.00 m

Bowdens Silver Project

Change in Peak Water Level,
2% AEP, Final Landform

0 200 400 600 m

wrm
water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak water level

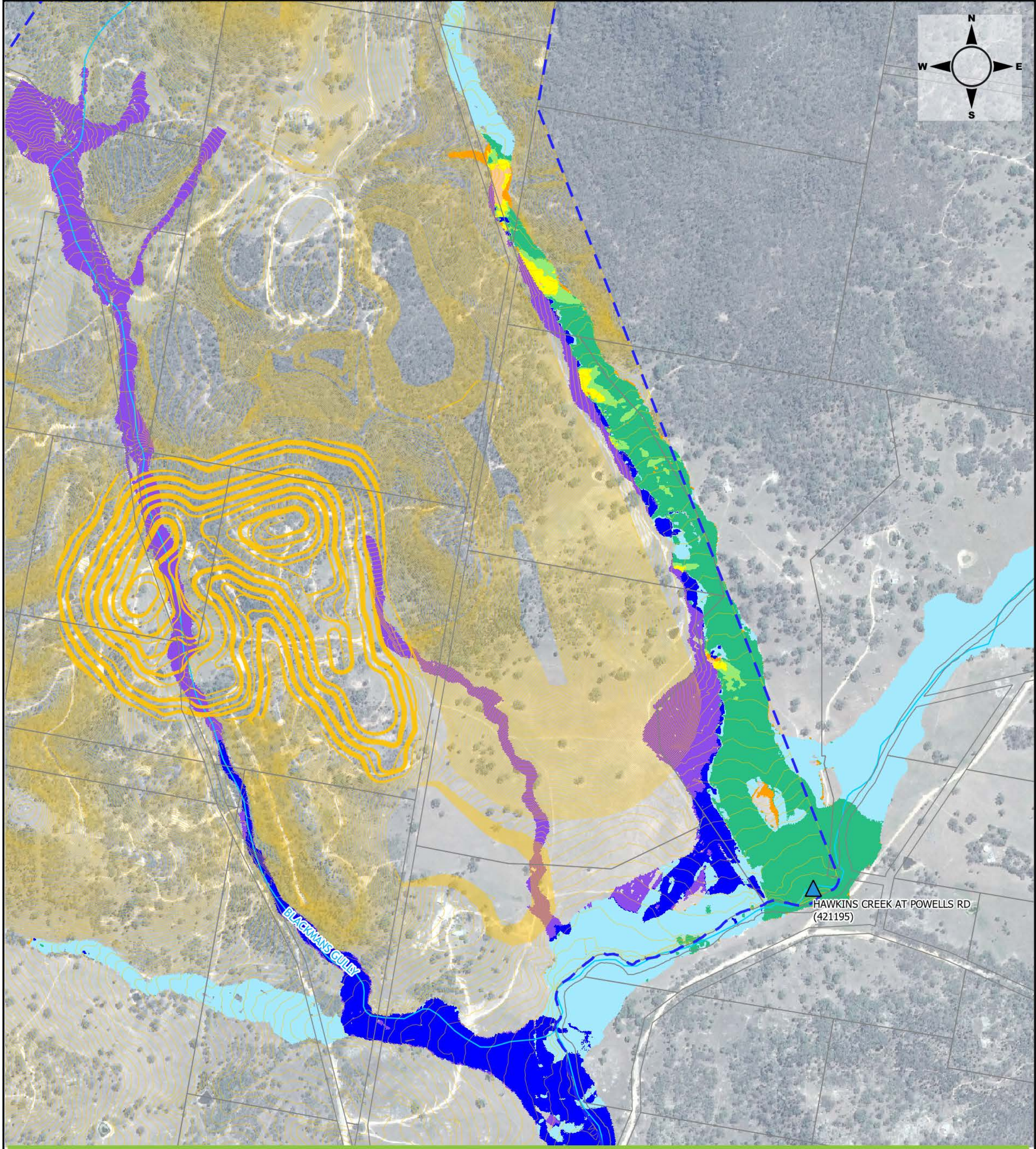
- < -1.00 m
- -1.00 m to -0.01 m
- -0.01 m to 0.01 m
- 0.01 m to 0.05 m
- 0.05 m to 0.10 m
- 0.10 m to 0.50 m
- 0.50 m to 1.00 m
- 1.00 m to 2.00 m
- 2.00 m to 3.00 m
- 3.00 m to 5.00 m
- > 5.00 m

Bowdens Silver Project

Change in Peak Water Level,
1% AEP, Final Landform

0 200 400 600 m

wrm
water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak water level

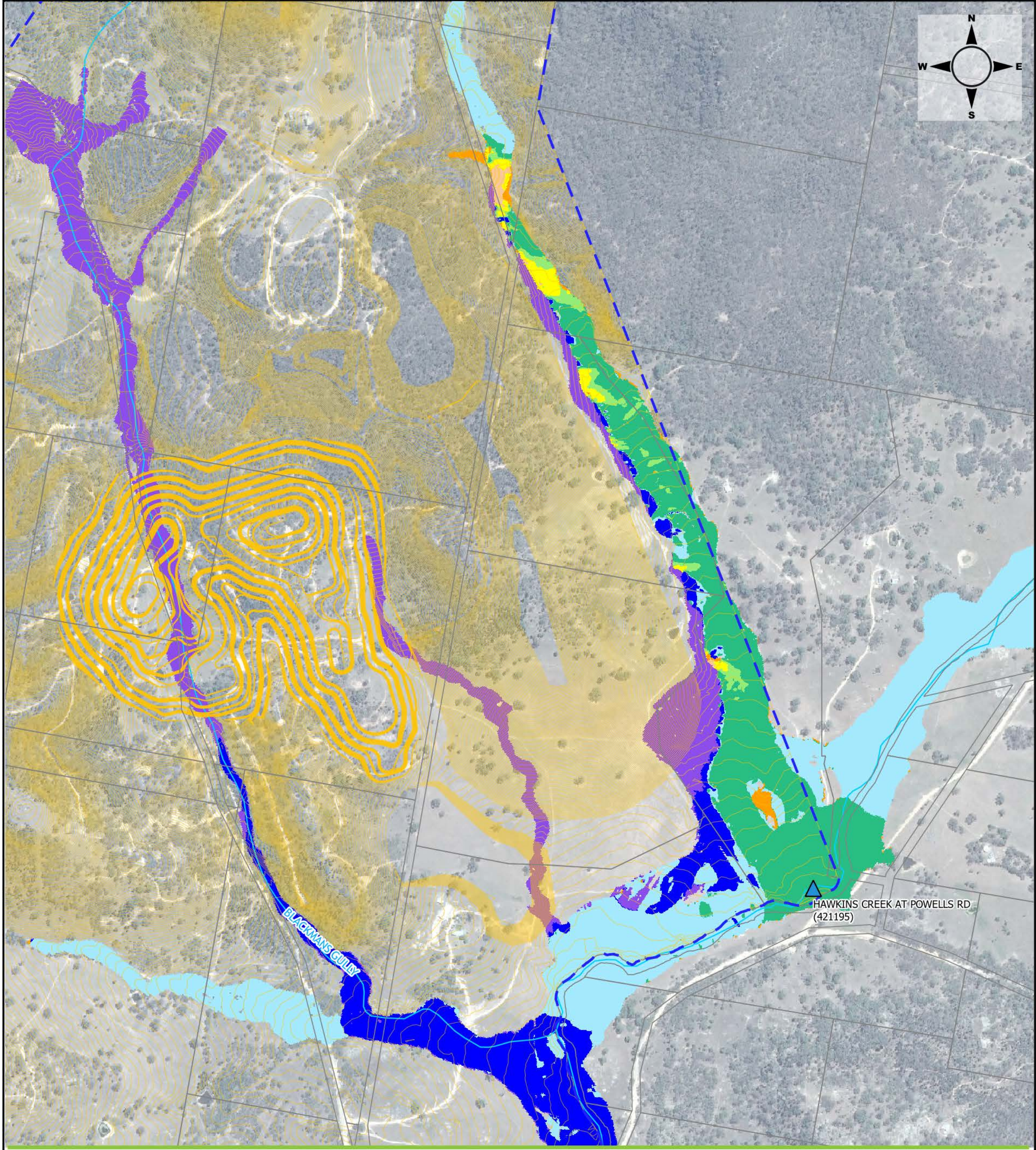
- < -1.00 m
- -1.00 m to -0.01 m
- -0.01 m to 0.01 m
- 0.01 m to 0.05 m
- 0.05 m to 0.10 m
- 0.10 m to 0.50 m
- 0.50 m to 1.00 m
- 1.00 m to 2.00 m
- 2.00 m to 3.00 m
- 3.00 m to 5.00 m
- > 5.00 m

Bowdens Silver Project

Change in Peak Water Level,
0.5% AEP, Final Landform

0 200 400 600 m

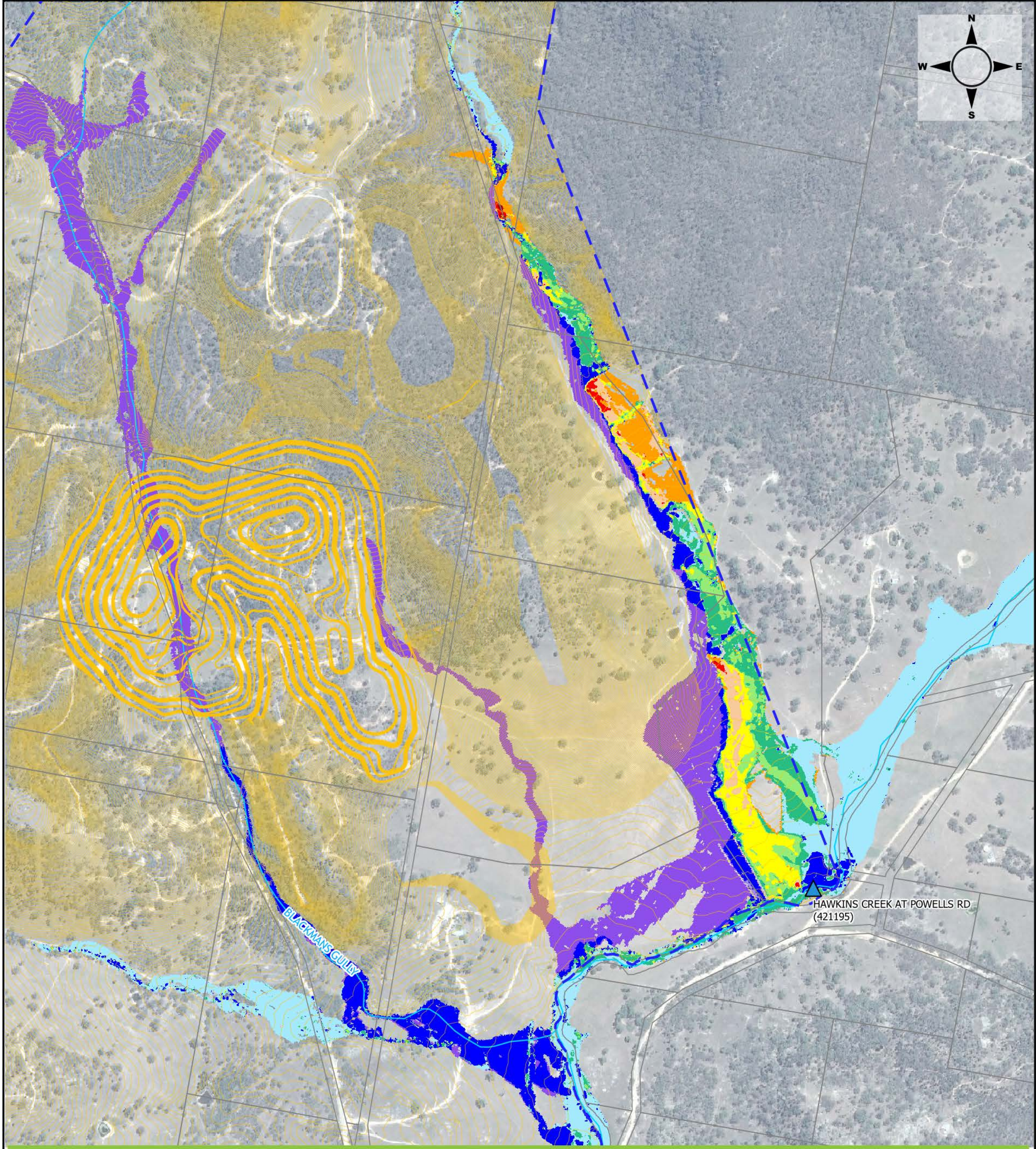
wrm water + environment



Bowdens Silver Project

Change in Peak Water Level,
0.2% AEP, Final Landform

wrm water + environment



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak velocity

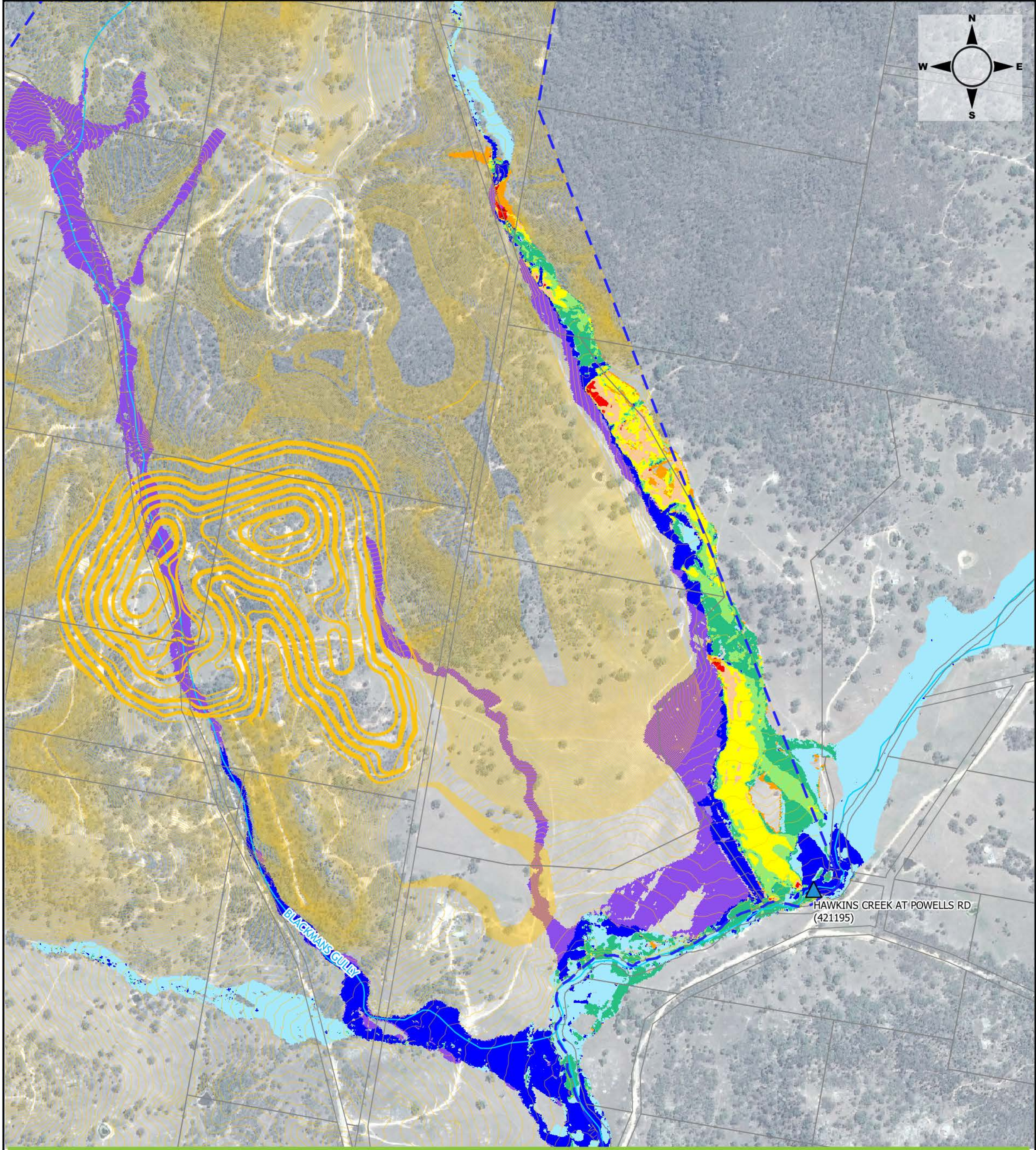
- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s

Bowdens Silver Project

Change in Peak Velocity,
10% AEP, Final Landform

0 200 400 600 m

Projection: MGA Zone 55 Datum: GDA 94



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak velocity

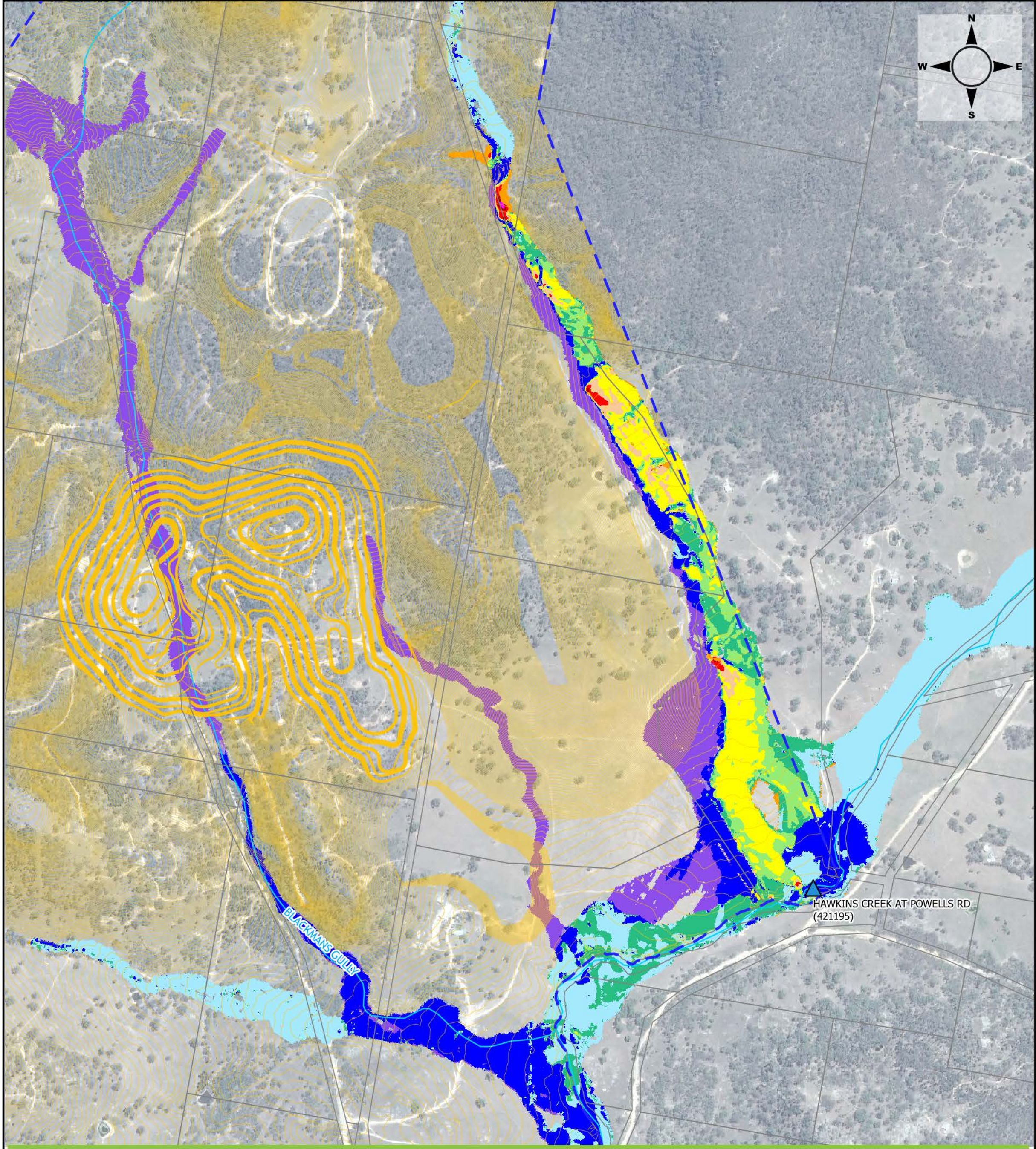
- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s

Bowdens Silver Project

Change in Peak Velocity,
5% AEP, Final Landform

0 200 400 600 m

wrm
water + environment



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak velocity

- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s

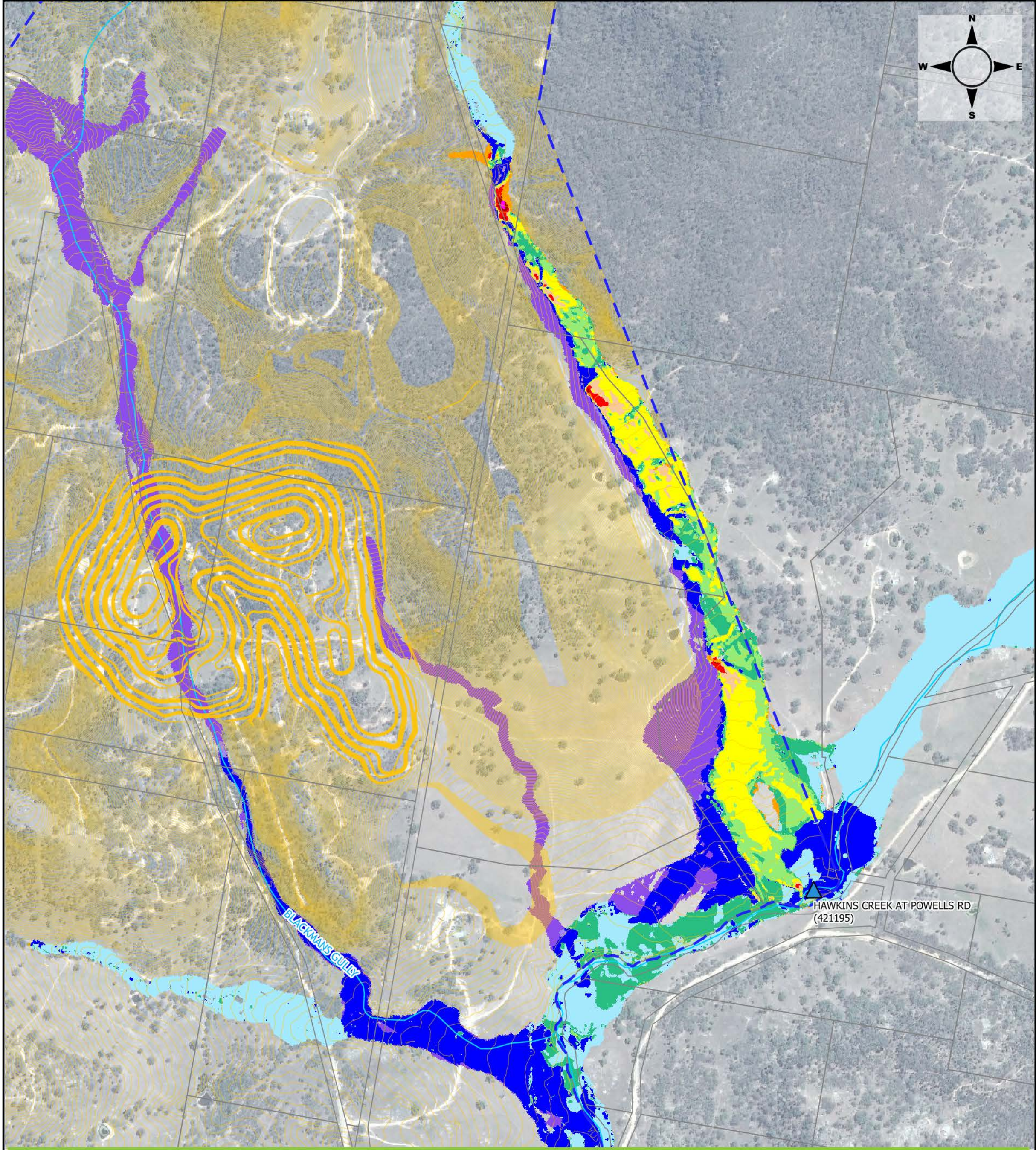
Bowdens Silver Project

Change in Peak Velocity,
2% AEP, Final Landform

0 200 400 600 m

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak velocity

- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s

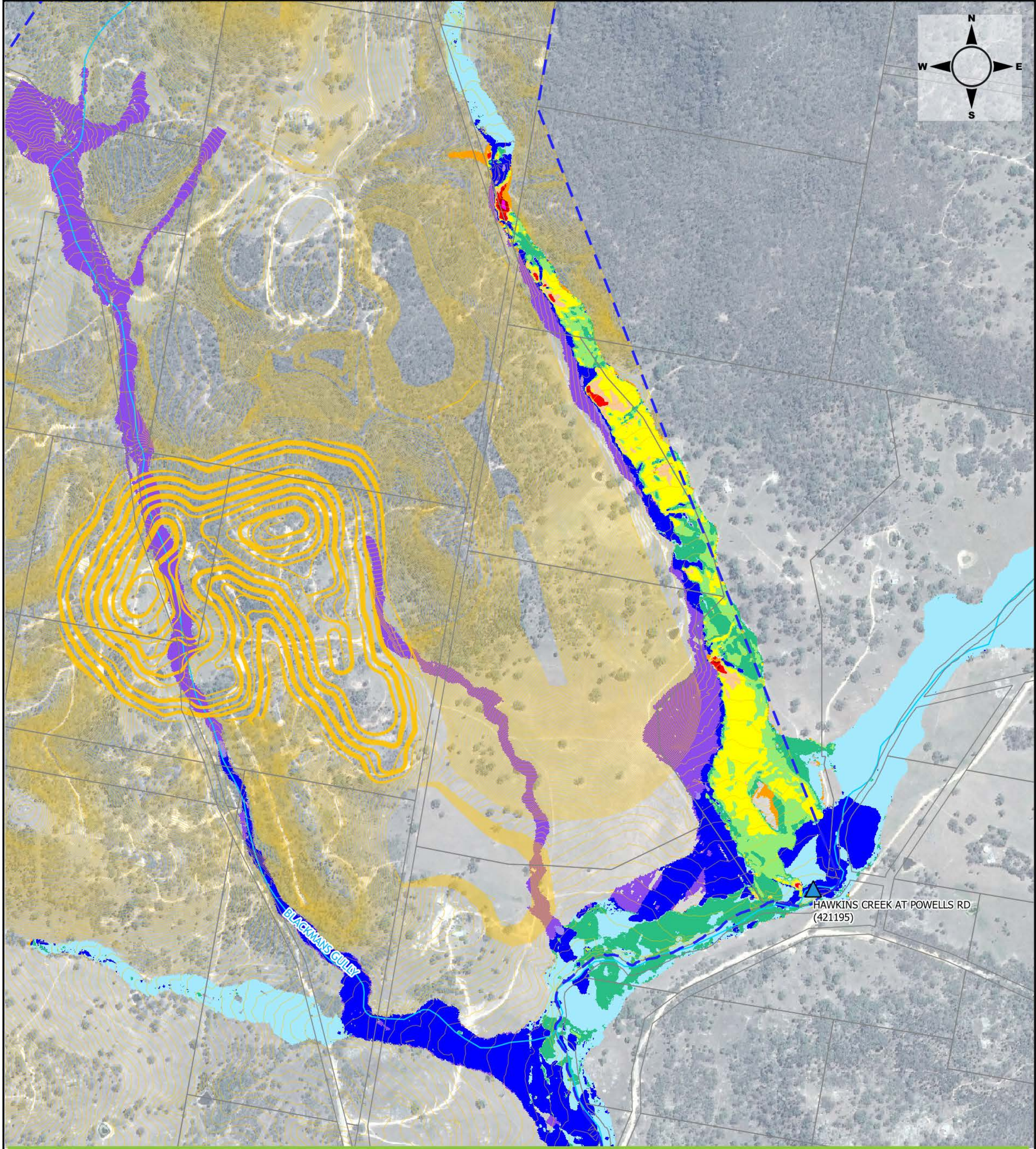
Bowdens Silver Project

Change in Peak Velocity,
1% AEP, Final Landform

0 200 400 600 m

wrm
water + environment

Projection: MGA Zone 55 Datum: GDA 94



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak velocity

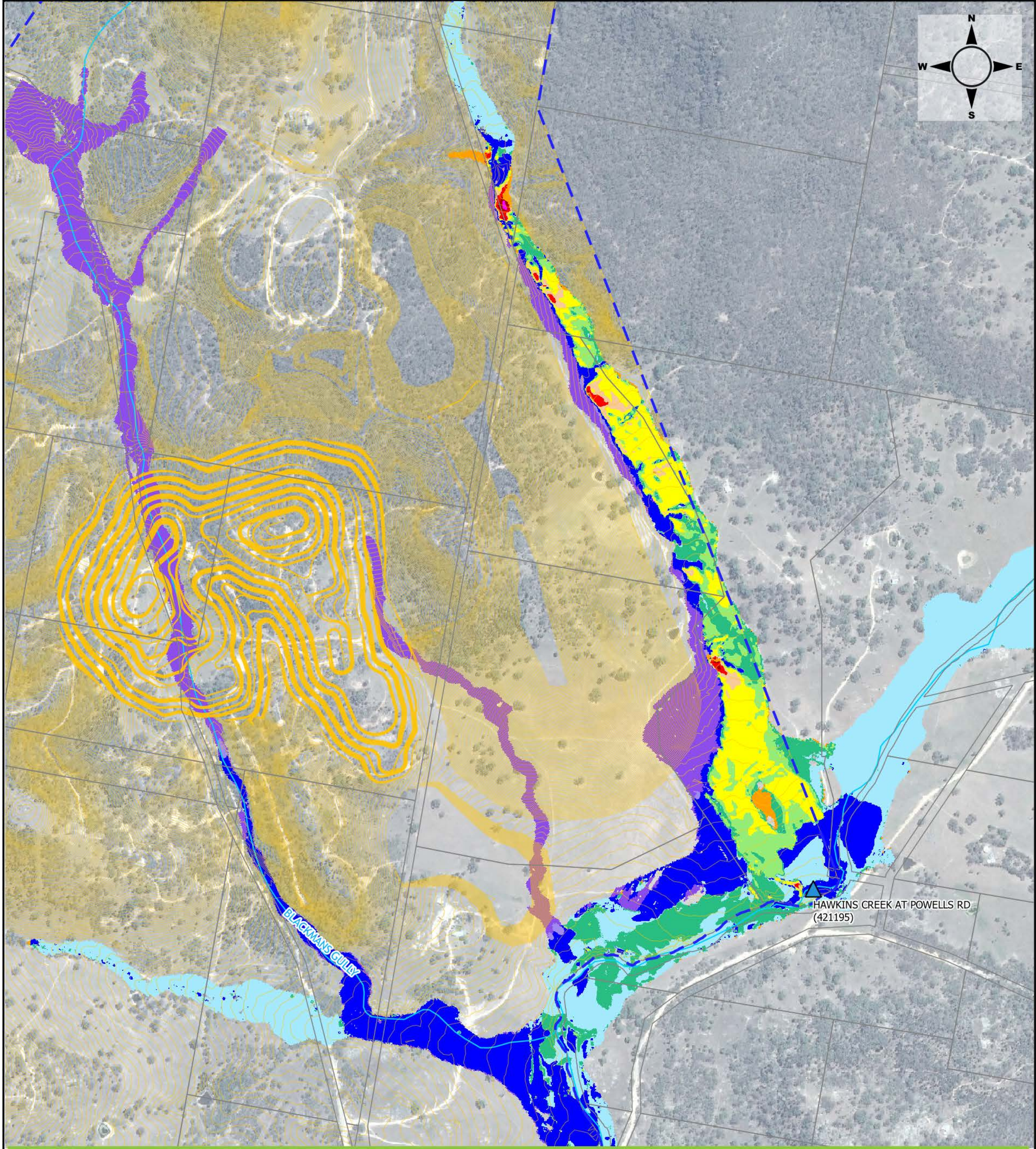
- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s

Bowdens Silver Project

Change in Peak Velocity,
0.5% AEP, Final Landform

0 200 400 600 m

wrm
water + environment



Legend

- Streamflow gauge
- Major watercourse
- Mine Site boundary
- Cadastre
- Mine plan contours (1 m interval)
- Was wet, now dry
- Was dry, now wet

Change in peak velocity

- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s

Bowdens Silver Project

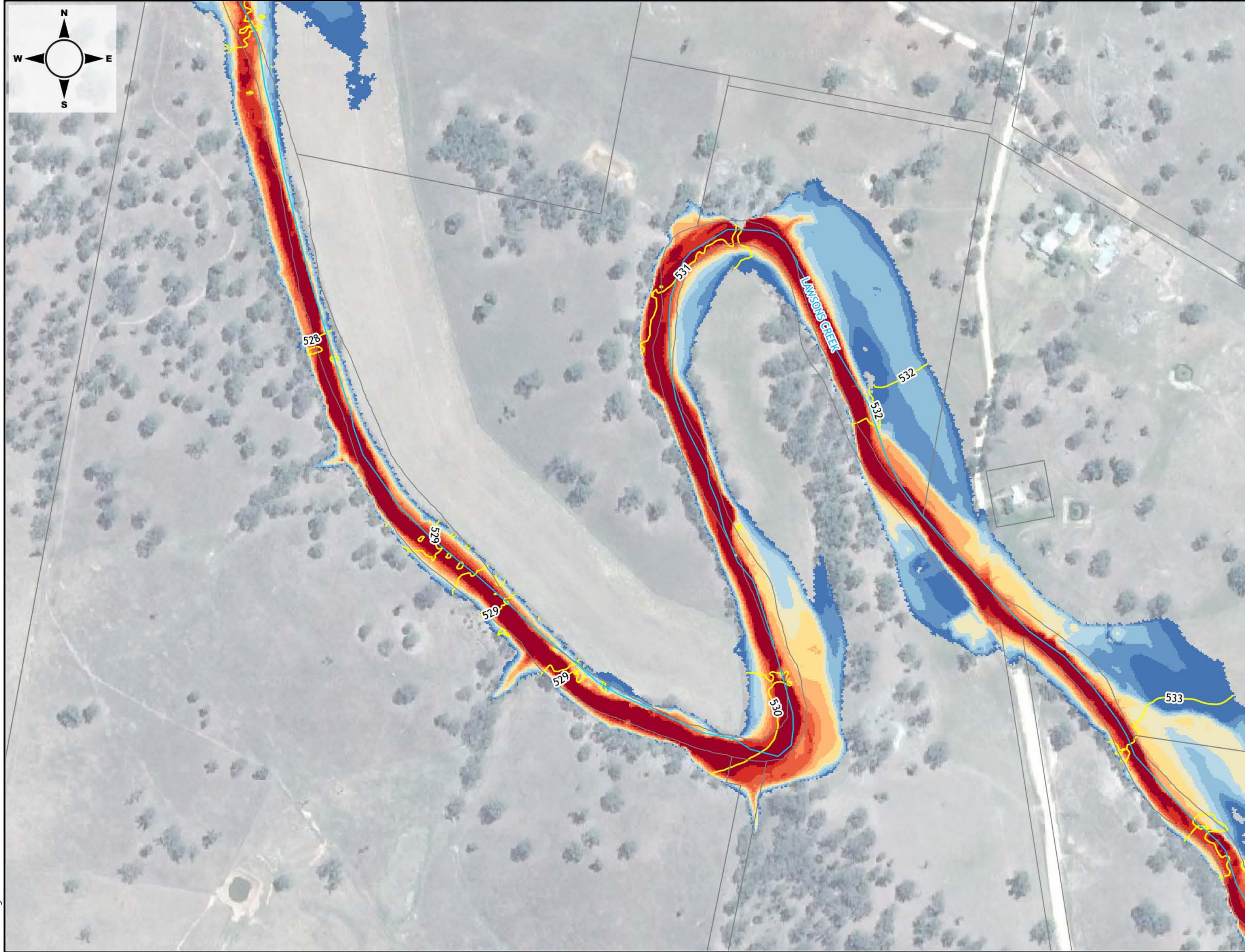
Change in Peak Velocity, 0.2% AEP, Final Landform

0 200 400 600 m

wrm water+environment

Projection: MGA Zone 55 Datum: GDA 94

Appendix F - Flood maps - Lawsons Creek crossing



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Major watercourse
- Cadastre

Depth

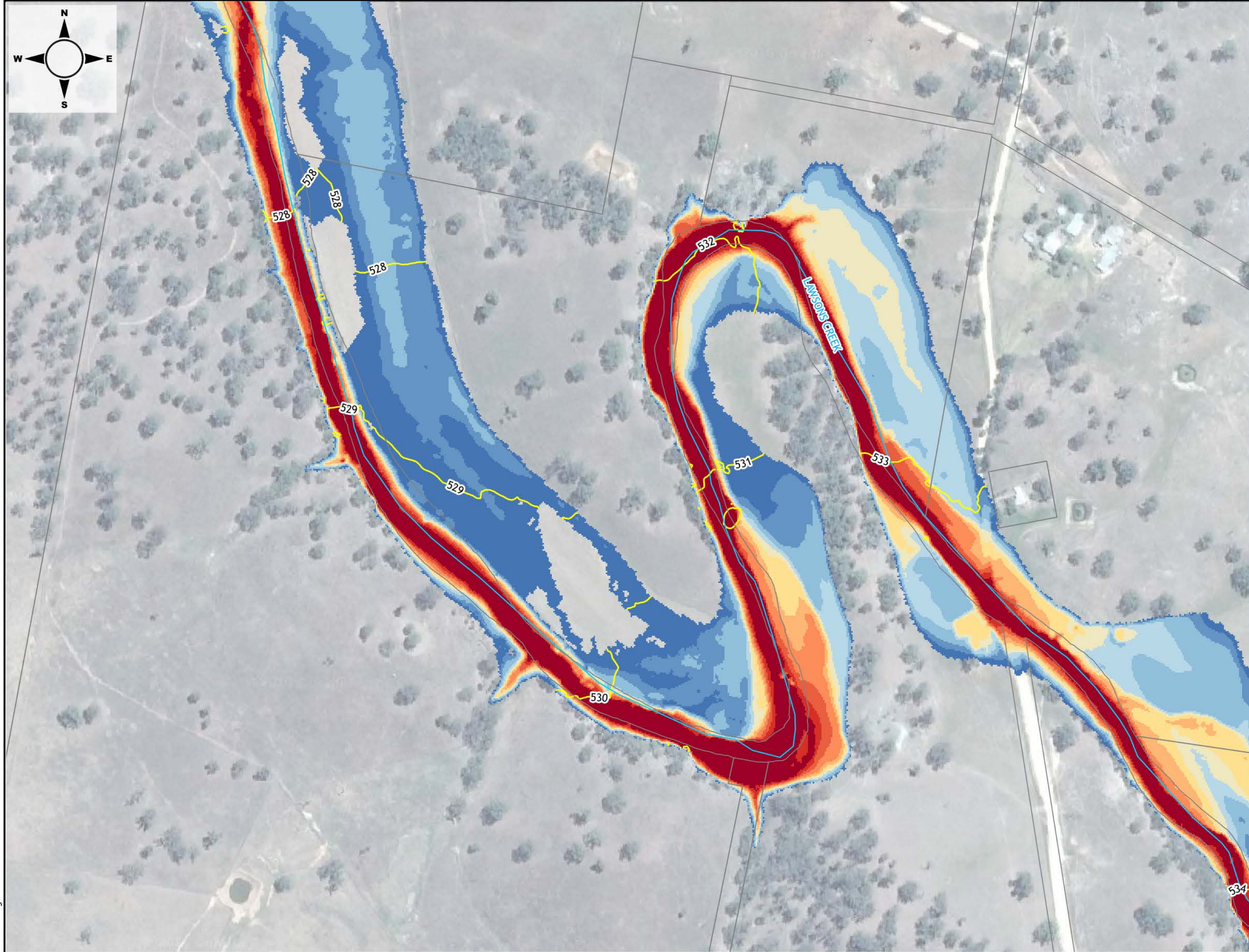
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

0 100 200 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 10% AEP

wrm water + environment



Legend

Major watercourse

Cadastre

Depth

0.00 m - 0.25 m

0.25 m - 0.50 m

0.50 m - 1.00 m

1.00 m - 1.50 m

1.50 m - 2.00 m

2.00 m - 2.50 m

2.50 m - 3.00 m

3.00 m - 3.50 m

3.50 m - 4.00 m

4.00 m - 4.50 m

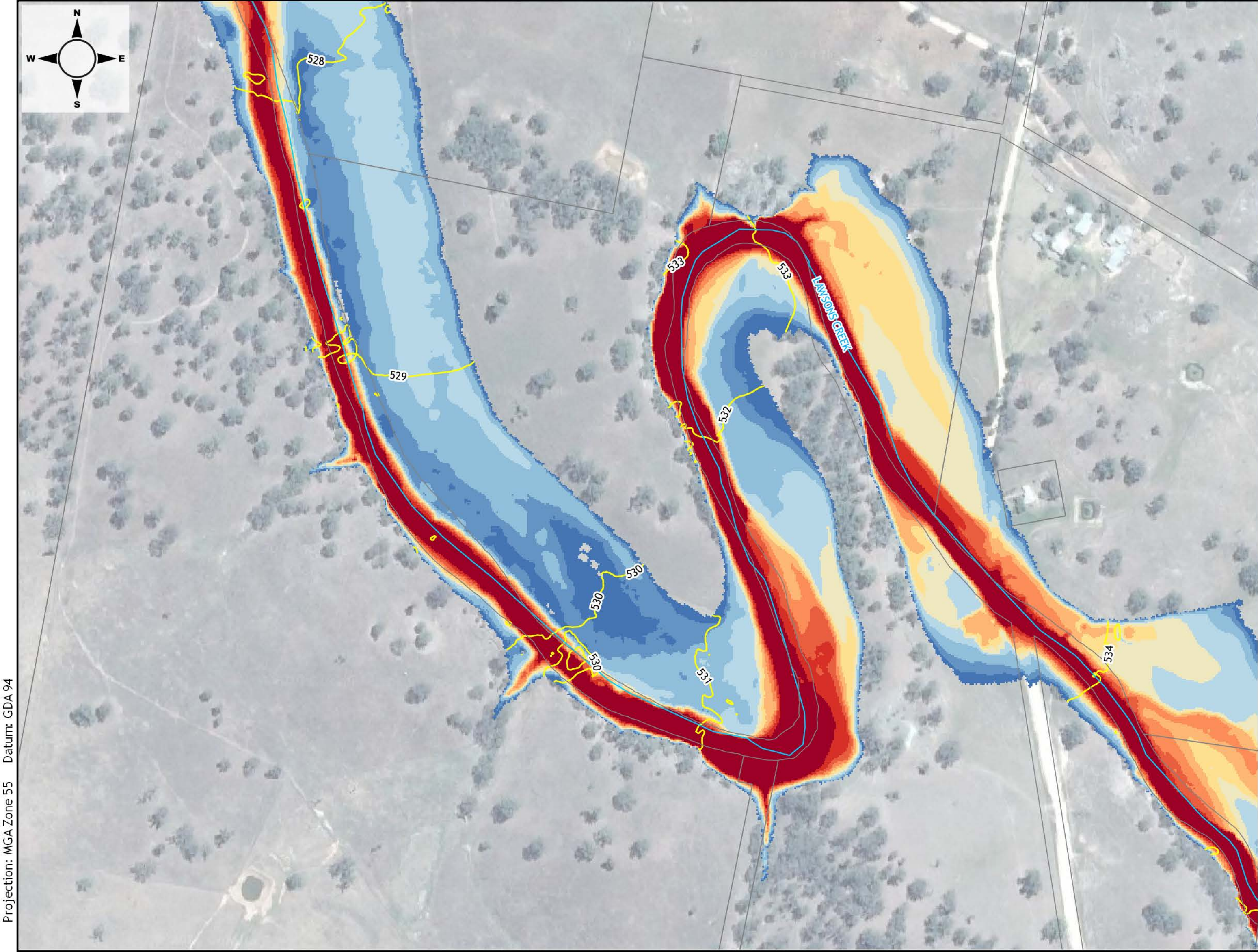
> 4.50 m

0 100 200 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 5% AEP

wrm water + environment



Legend

- Major watercourse
- Cadastre

Depth

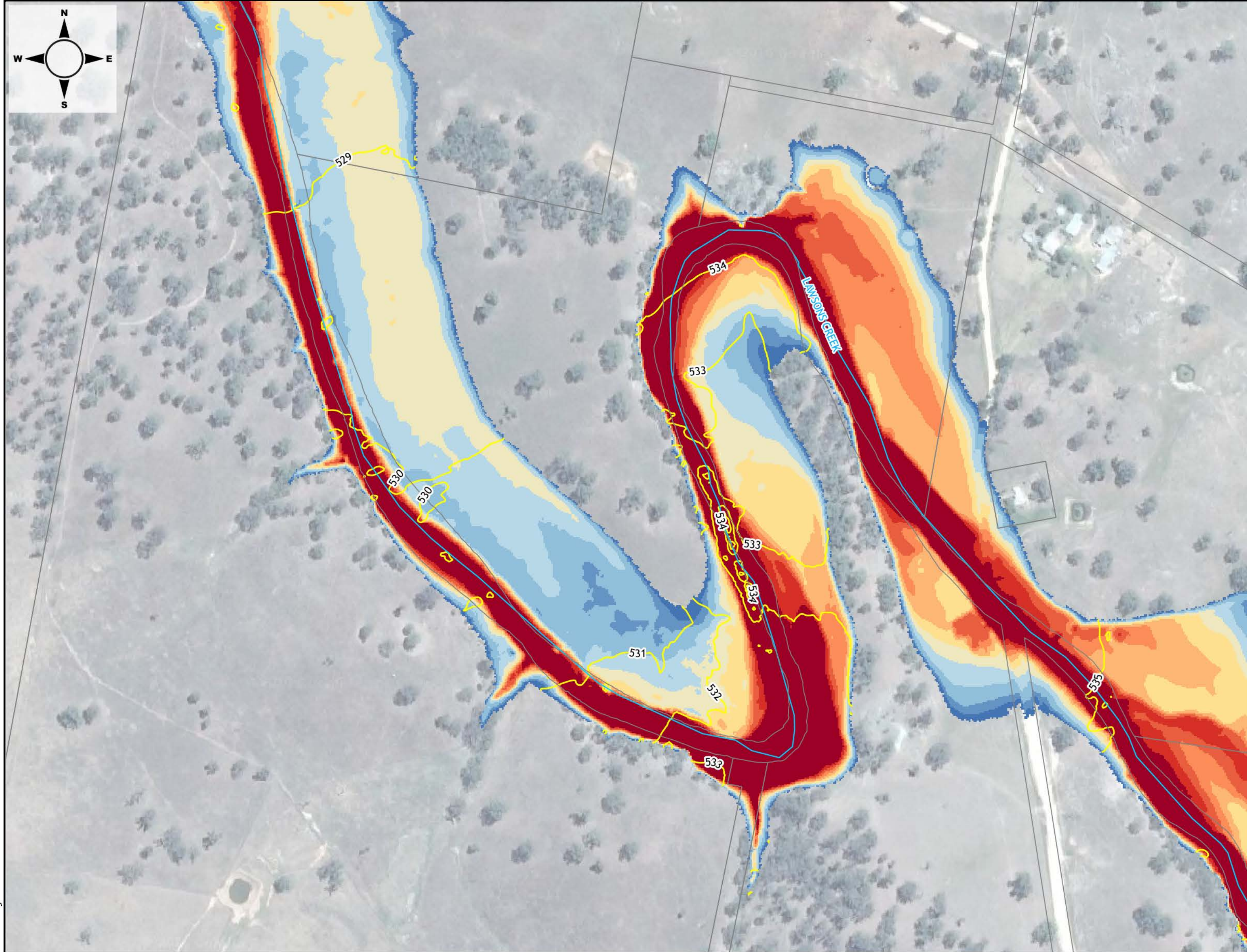
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

0 100 200 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 2% AEP

wrm water + environment



Legend

Major watercourse
Cadastre

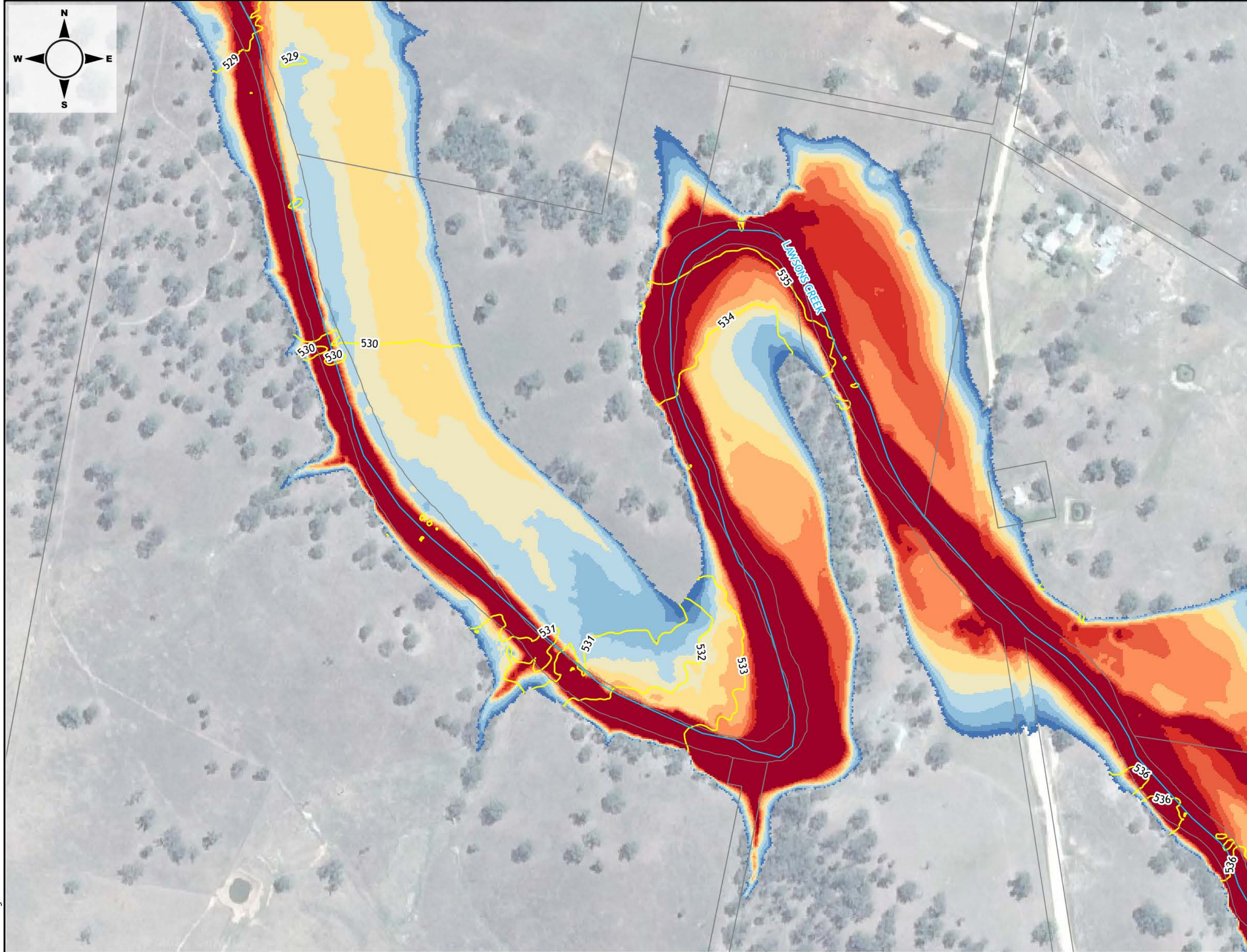
Depth
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 4.50 m
- > 4.50 m

0 100 200 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 1% AEP

wrm water + environment



Legend

Major watercourse

Cadastre

Depth

0.00 m - 0.25 m

0.25 m - 0.50 m

0.50 m - 1.00 m

1.00 m - 1.50 m

1.50 m - 2.00 m

2.00 m - 2.50 m

2.50 m - 3.00 m

3.00 m - 3.50 m

3.50 m - 4.00 m

4.00 m - 4.50 m

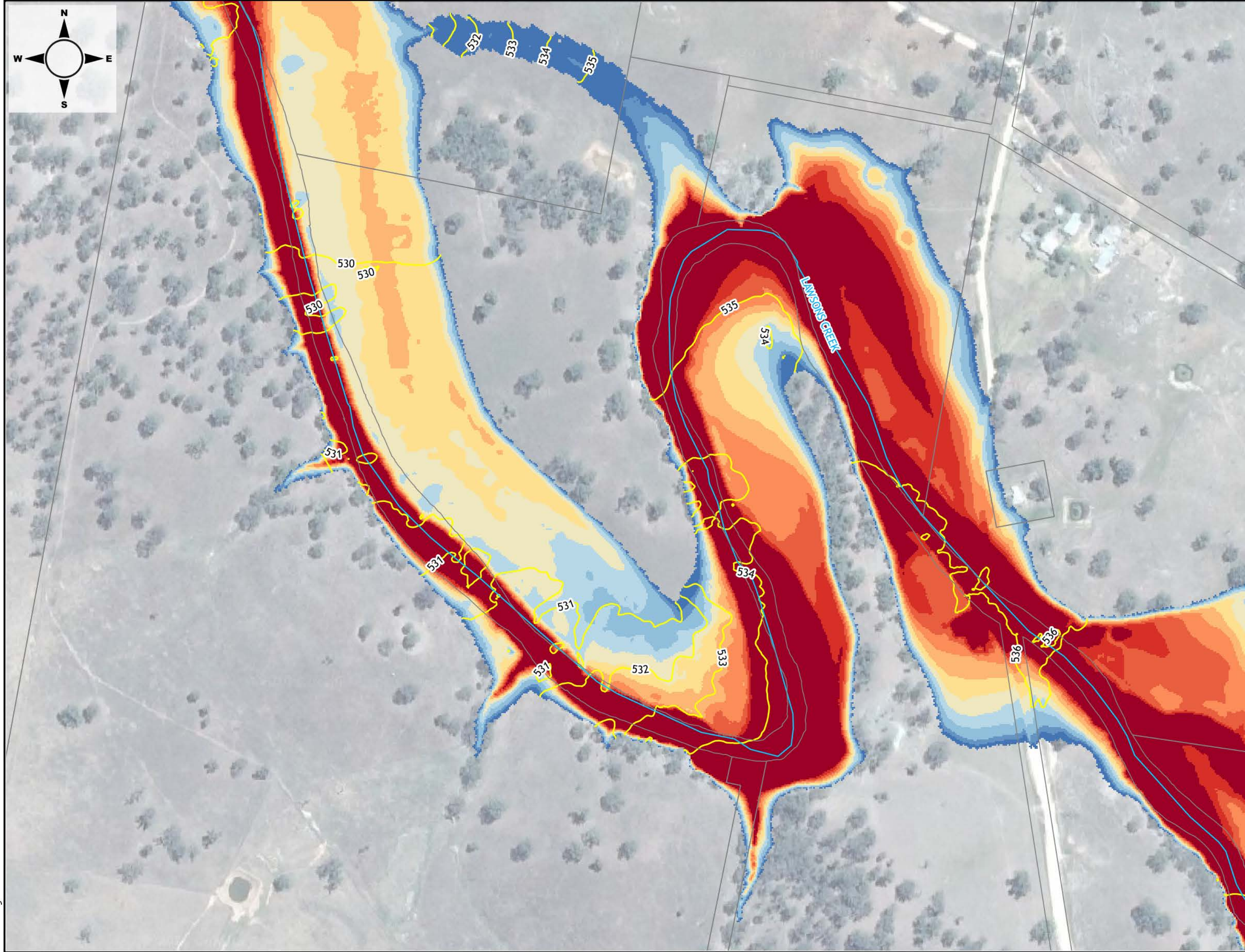
> 4.50 m

0 100 200 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 0.5% AEP

wrm water + environment



Legend

Major watercourse

Cadastre

Depth

0.00 m - 0.25 m

0.25 m - 0.50 m

0.50 m - 1.00 m

1.00 m - 1.50 m

1.50 m - 2.00 m

2.00 m - 2.50 m

2.50 m - 3.00 m

3.00 m - 3.50 m

3.50 m - 4.00 m

4.00 m - 4.50 m

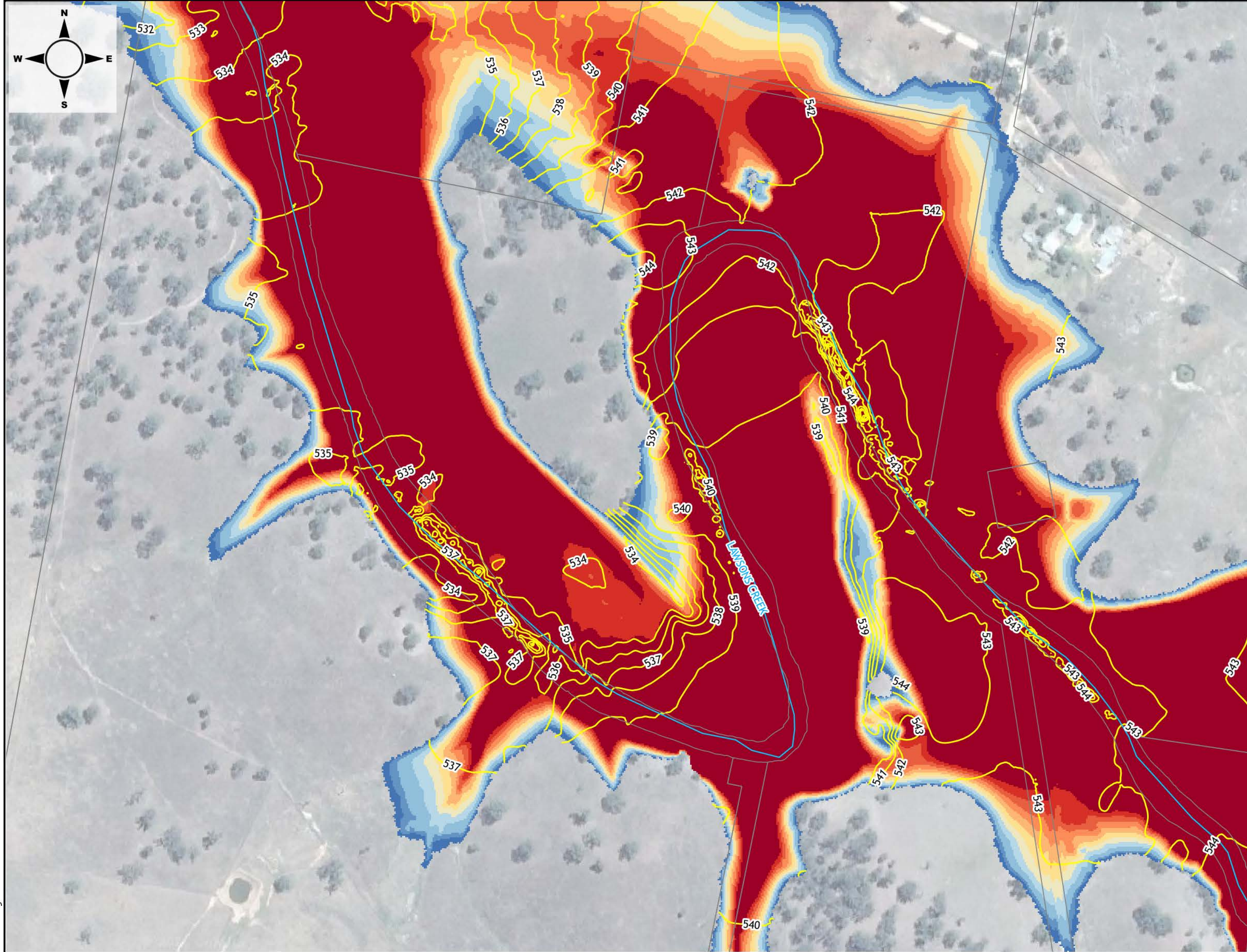
> 4.50 m

0 100 200 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), 0.2% AEP

wrm water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

Major watercourse

Cadastre

Depth

0.00 m - 0.25 m

0.25 m - 0.50 m

0.50 m - 1.00 m

1.00 m - 1.50 m

1.50 m - 2.00 m

2.00 m - 2.50 m

2.50 m - 3.00 m

3.00 m - 3.50 m

3.50 m - 4.00 m

4.00 m - 4.50 m

> 4.50 m

0 100 200 m

Bowdens Silver Project

Predicted Flood Extents & Depths (Existing Condition), PMF

wrm water + environment

Legend

Major watercourse
Cadastre

Velocity

0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s

0 100 200 m

Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 10% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 5% AEP

Legend

Major watercourse

Cadastre

Velocity

0.0 m/s < 0.5 m/s

0.5 m/s < 1.0 m/s

1.0 m/s < 1.5 m/s

1.5 m/s < 2.0 m/s

2.0 m/s < 2.5 m/s

2.5 m/s < 3.0 m/s

3.0 m/s < 4.0 m/s

> 4.0 m/s

0 100 200 m

Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 2% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

Legend

Major watercourse

Cadastre

Velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

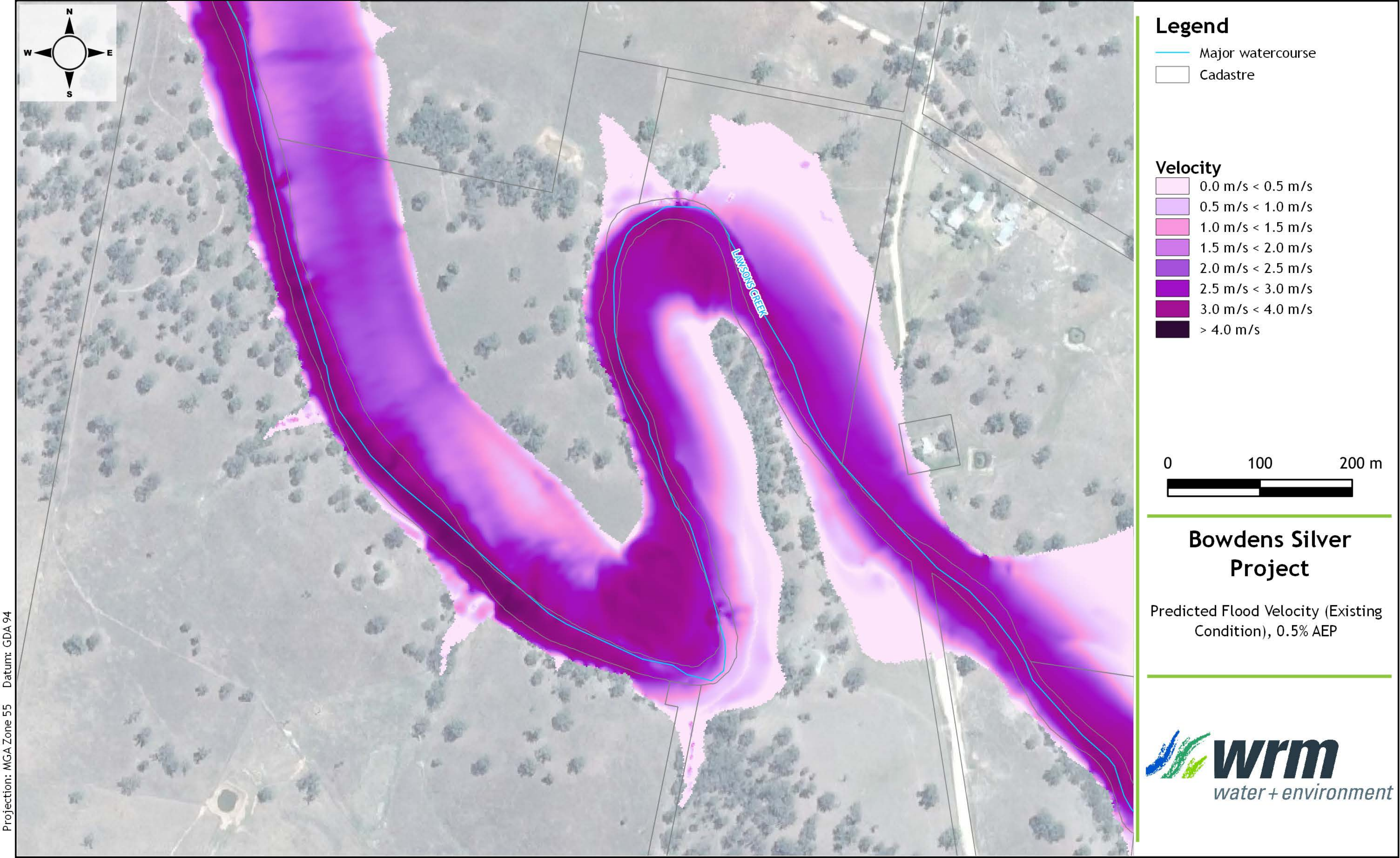
0 100 200 m

Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 1% AEP

wrm water + environment

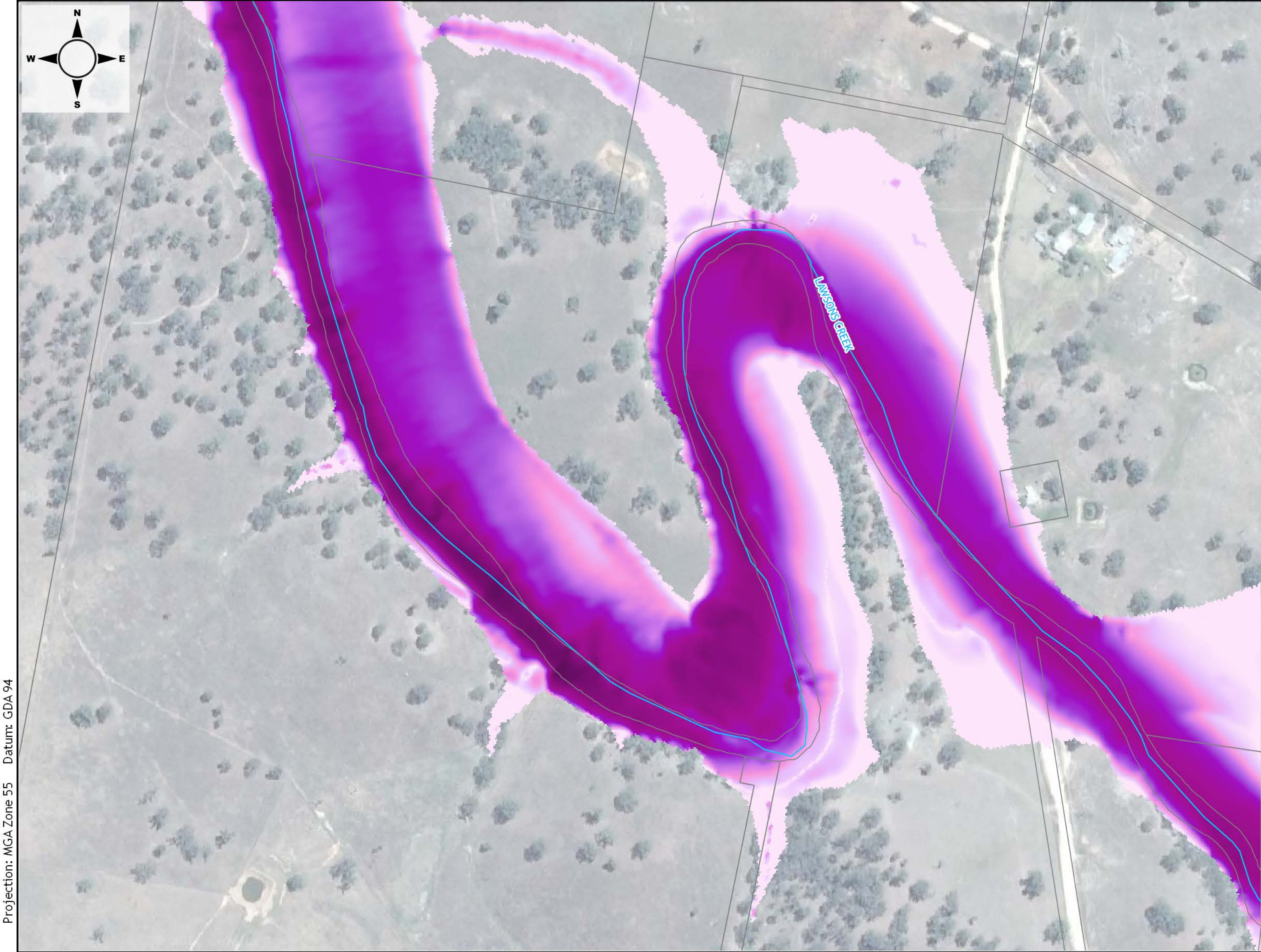
Projection: MGA Zone 55 Datum: GDA 94



Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 0.5% AEP

wrm water + environment



Legend

Major watercourse

Cadastre

Velocity

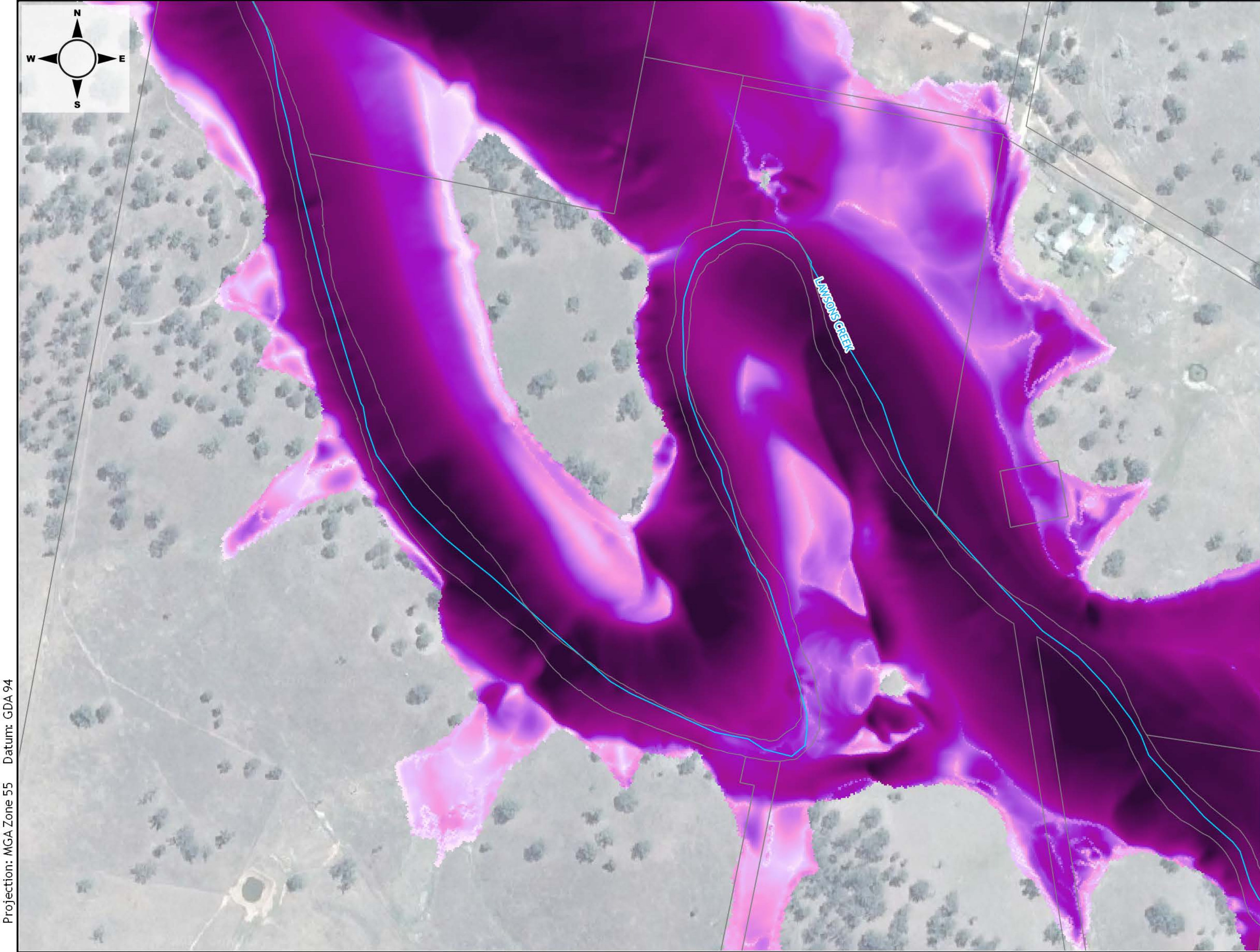
- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- \> 4.0 m/s

0 100 200 m

Bowdens Silver Project

Predicted Flood Velocity (Existing Condition), 0.2% AEP

wrm water + environment



Legend

Major watercourse

Cadastre

Velocity

0.0 m/s < 0.5 m/s

0.5 m/s < 1.0 m/s

1.0 m/s < 1.5 m/s

1.5 m/s < 2.0 m/s

2.0 m/s < 2.5 m/s

2.5 m/s < 3.0 m/s

3.0 m/s < 4.0 m/s

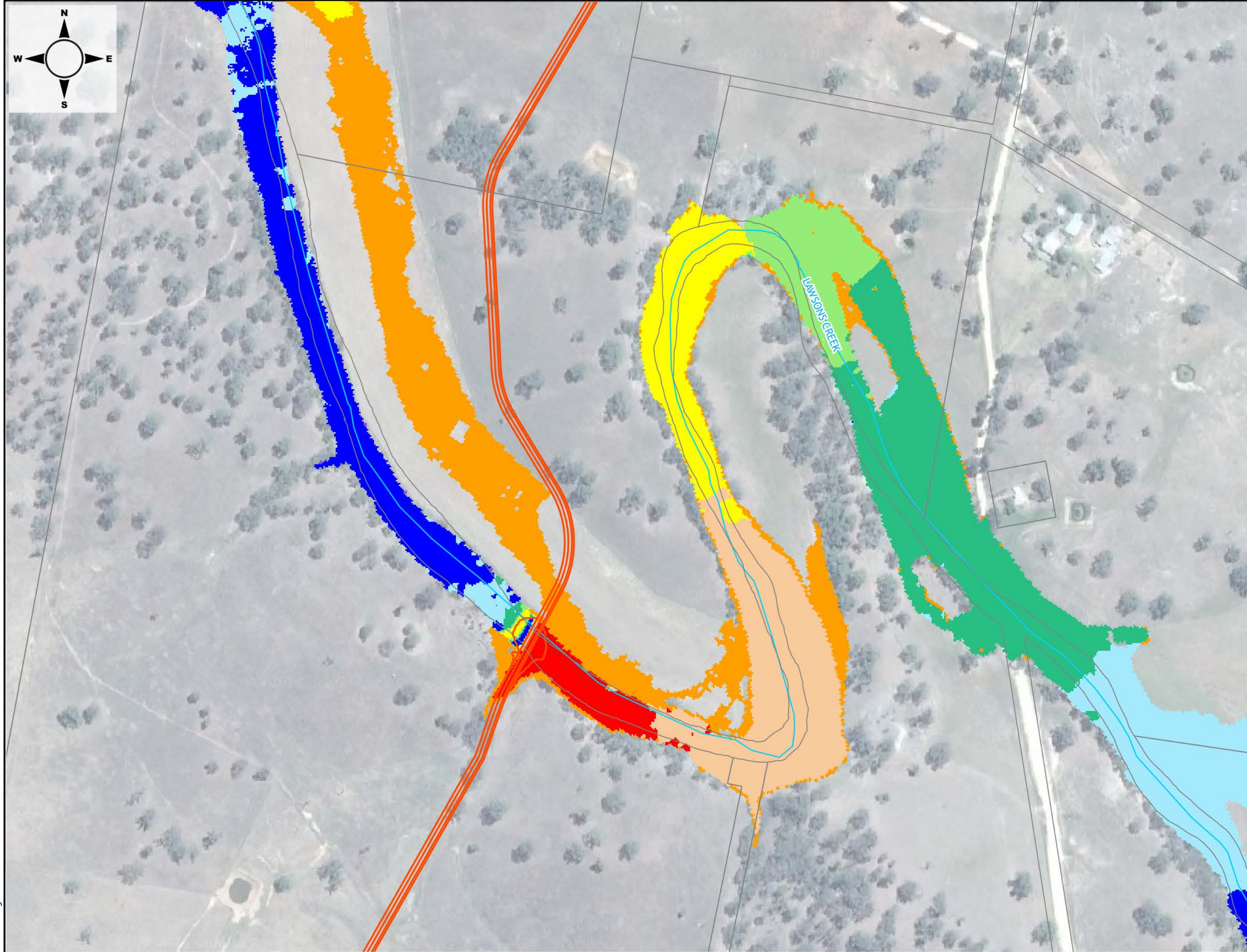
> 4.0 m/s

0 100 200 m

Bowdens Silver Project

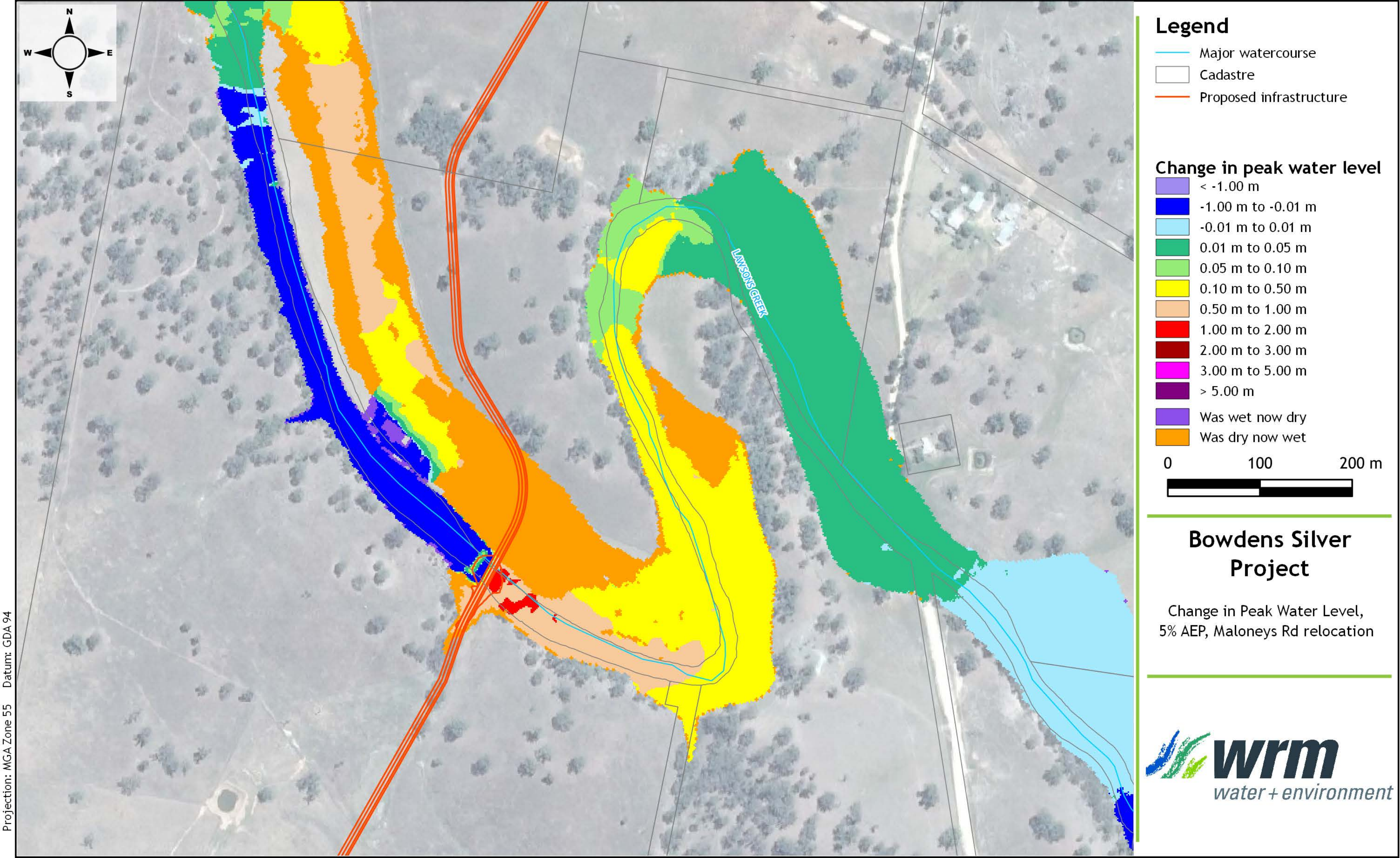
Predicted Flood Velocity (Existing Condition), PMF

wrm water+environment



Bowdens Silver Project

Change in Peak Water Level, 10% AEP, Maloneys Rd relocation


N
S
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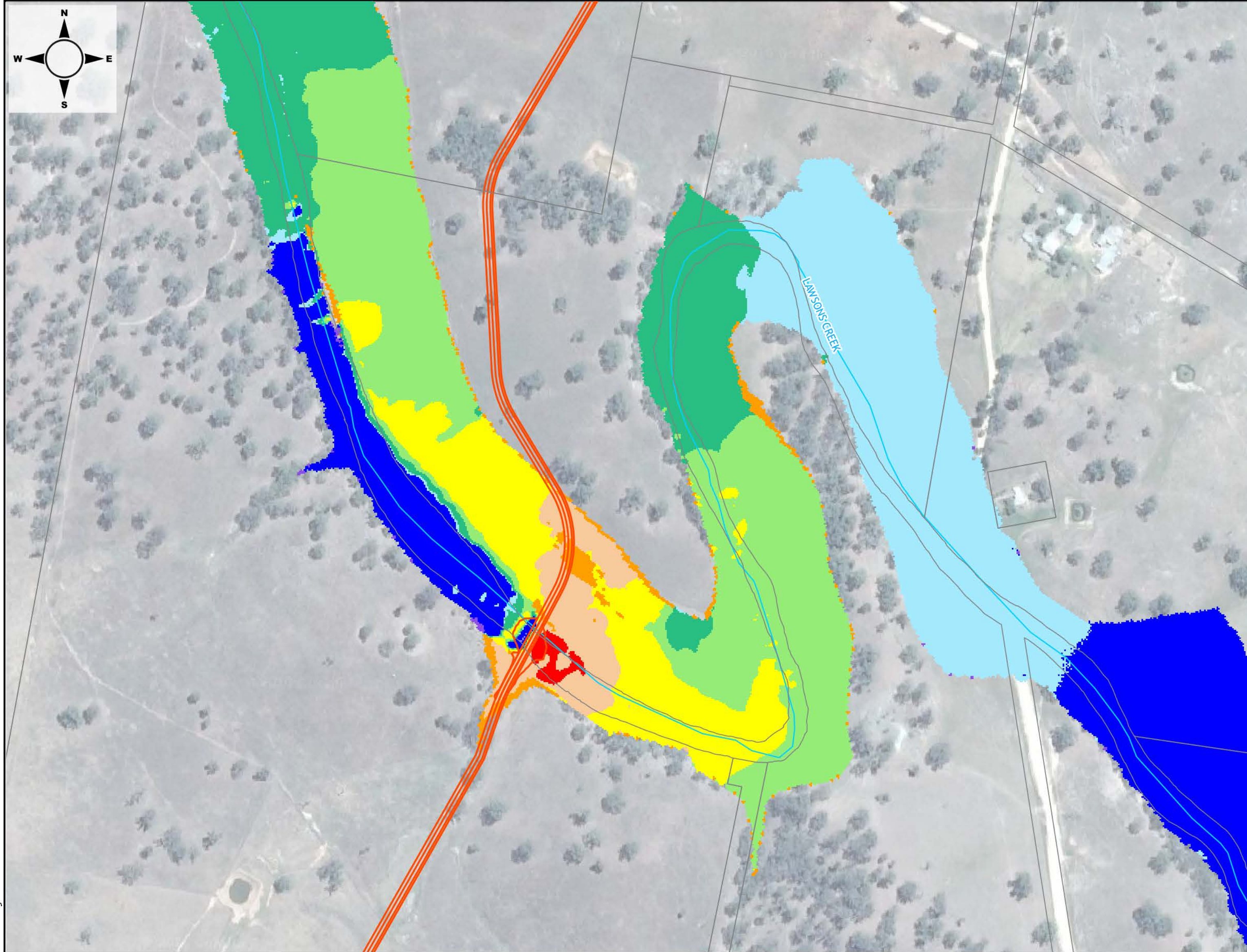
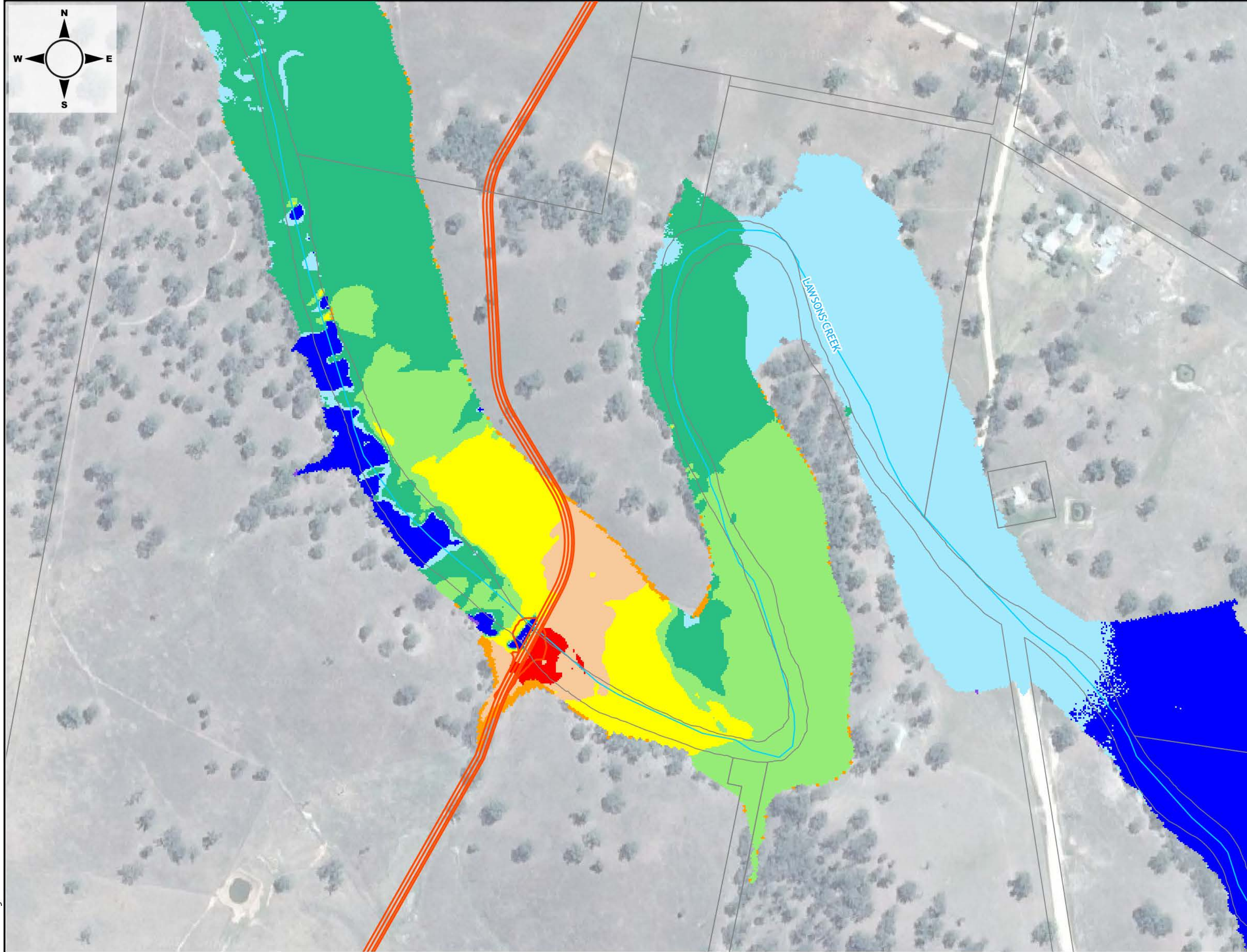
LAWSONS CREEK
Legend
Major watercourse
Cadastre
Proposed infrastructure
Change in peak water level
< -1.00 m
-1.00 m to -0.01 m
-0.01 m to 0.01 m
0.01 m to 0.05 m
0.05 m to 0.10 m
0.10 m to 0.50 m
0.50 m to 1.00 m
1.00 m to 2.00 m
2.00 m to 3.00 m
3.00 m to 5.00 m
> 5.00 m
Was wet now dry
Was dry now wet
0
100
200 m
Bowdens Silver Project
Change in Peak Water Level, 5% AEP, Maloneys Rd relocation
wrm
water + environment
Projection: MGA Zone 55 Datum: GDA 94



Bowdens Silver Project

Change in Peak Water Level, 2% AEP, Maloneys Rd relocation

wrm water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Major watercourse
- Cadastre
- Proposed infrastructure

Change in peak water level

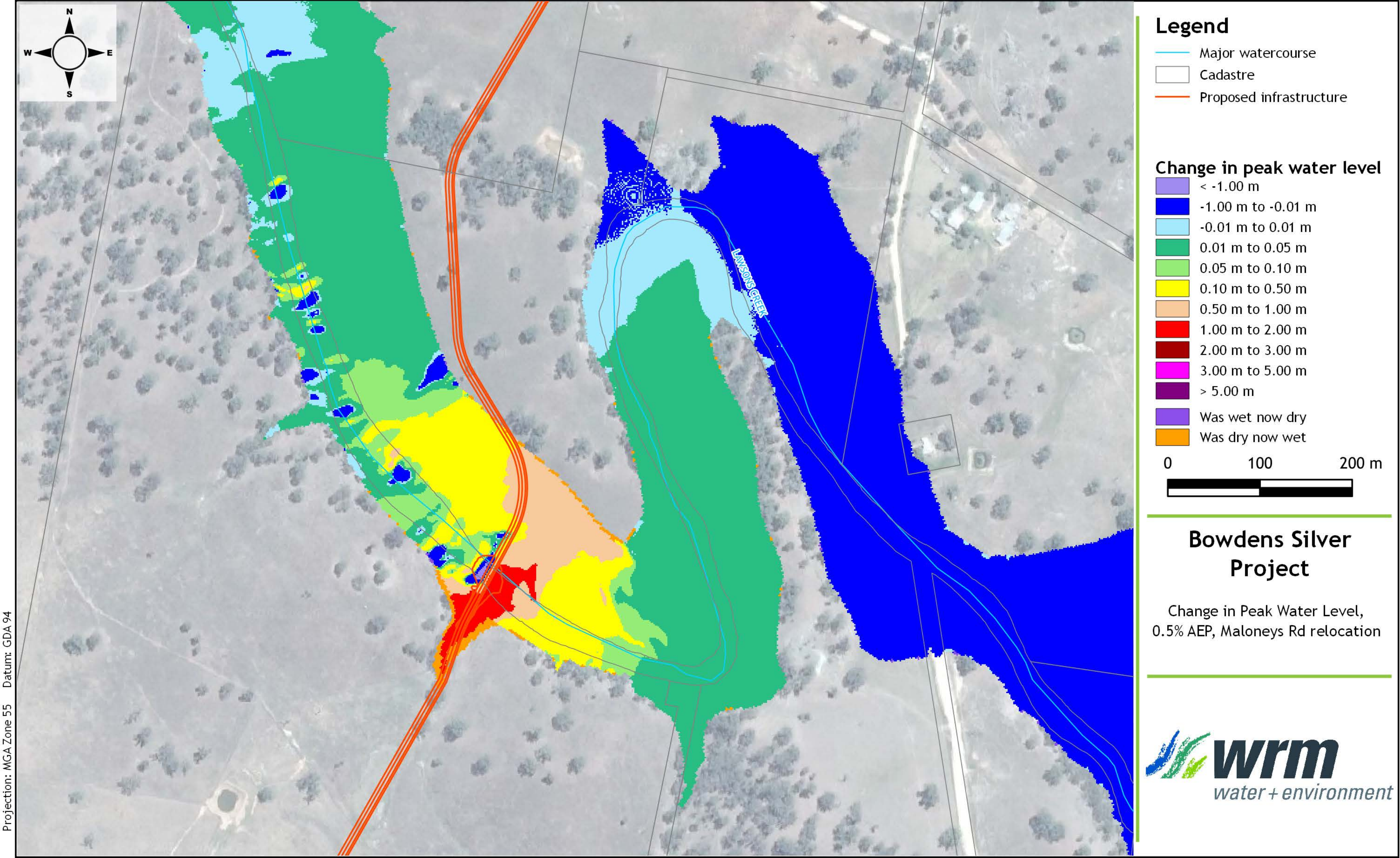
- < -1.00 m
- -1.00 m to -0.01 m
- -0.01 m to 0.01 m
- 0.01 m to 0.05 m
- 0.05 m to 0.10 m
- 0.10 m to 0.50 m
- 0.50 m to 1.00 m
- 1.00 m to 2.00 m
- 2.00 m to 3.00 m
- 3.00 m to 5.00 m
- > 5.00 m
- Was wet now dry
- Was dry now wet

0 100 200 m

Bowdens Silver Project

Change in Peak Water Level, 1% AEP, Maloneys Rd relocation

wrm water + environment


N
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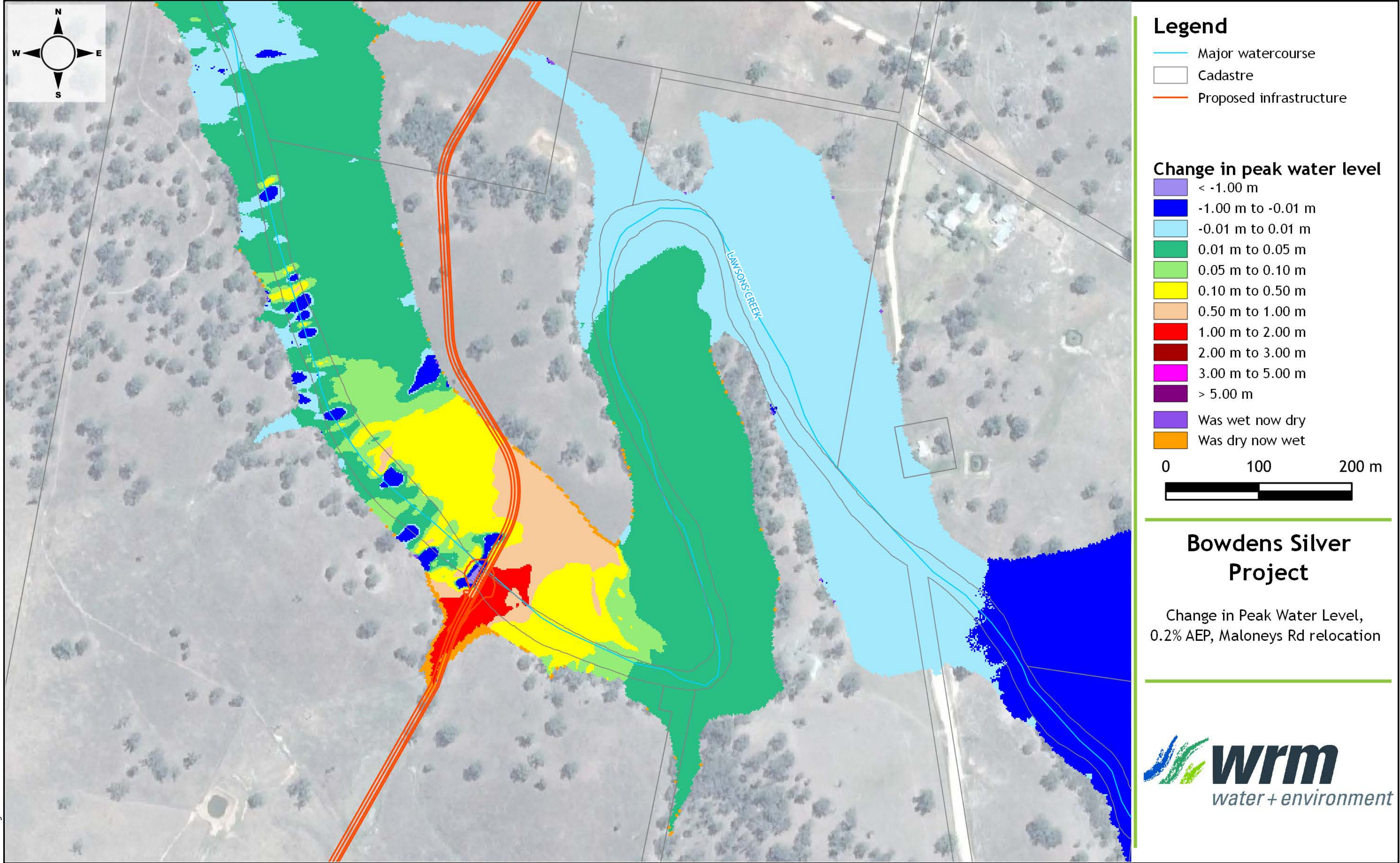
S
LAWSONS CREEK
Legend
Major watercourse
Cadastre
Proposed infrastructure
Change in peak water level
< -1.00 m
-1.00 m to -0.01 m
-0.01 m to 0.01 m
0.01 m to 0.05 m
0.05 m to 0.10 m
0.10 m to 0.50 m
0.50 m to 1.00 m
1.00 m to 2.00 m
2.00 m to 3.00 m
3.00 m to 5.00 m
> 5.00 m
Was wet now dry
Was dry now wet
0
100
200 m
Bowdens Silver Project
Change in Peak Water Level, 0.5% AEP, Maloneys Rd relocation
wrm
water + environment
Projection: MGA Zone 55 Datum: GDA 94


N
W
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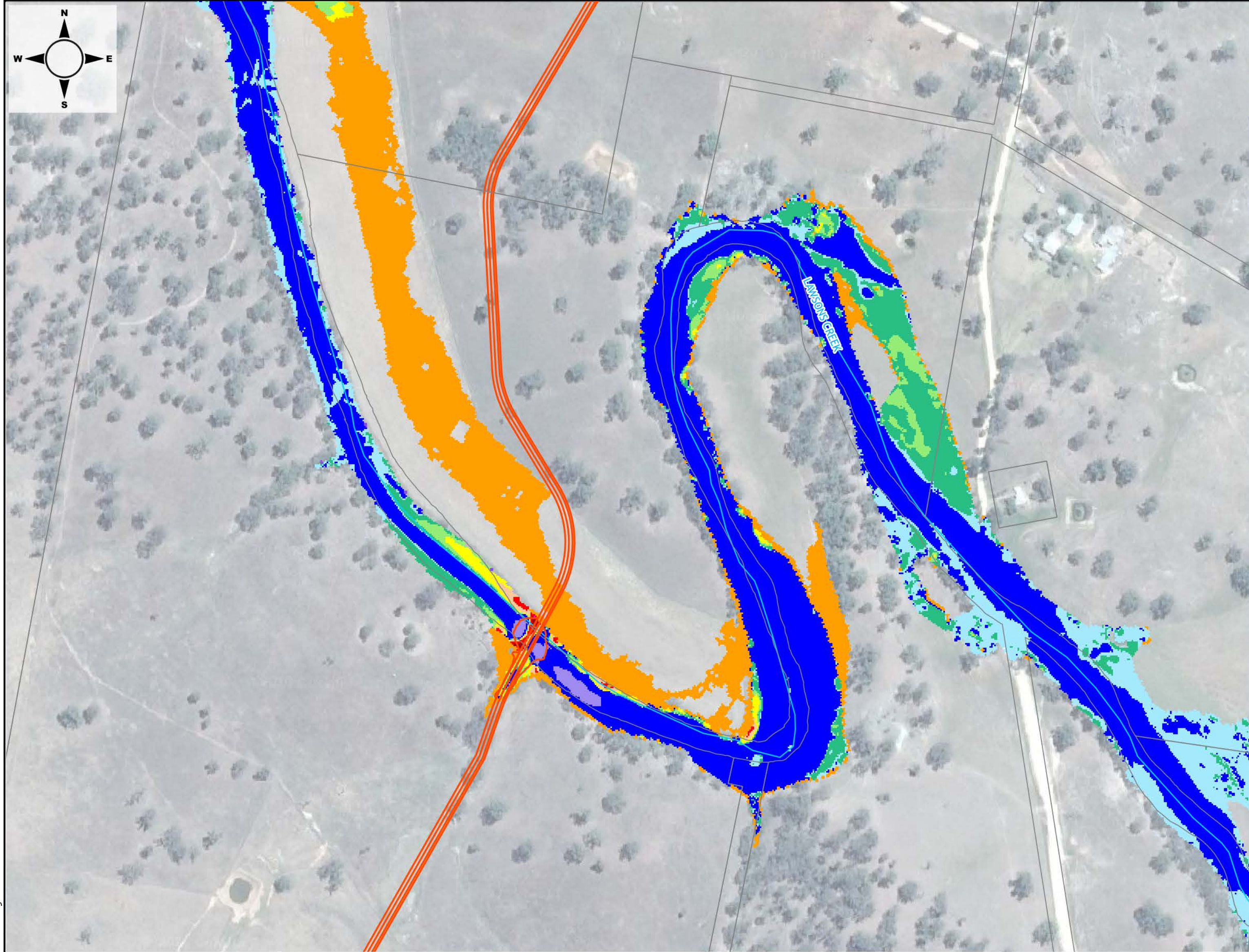
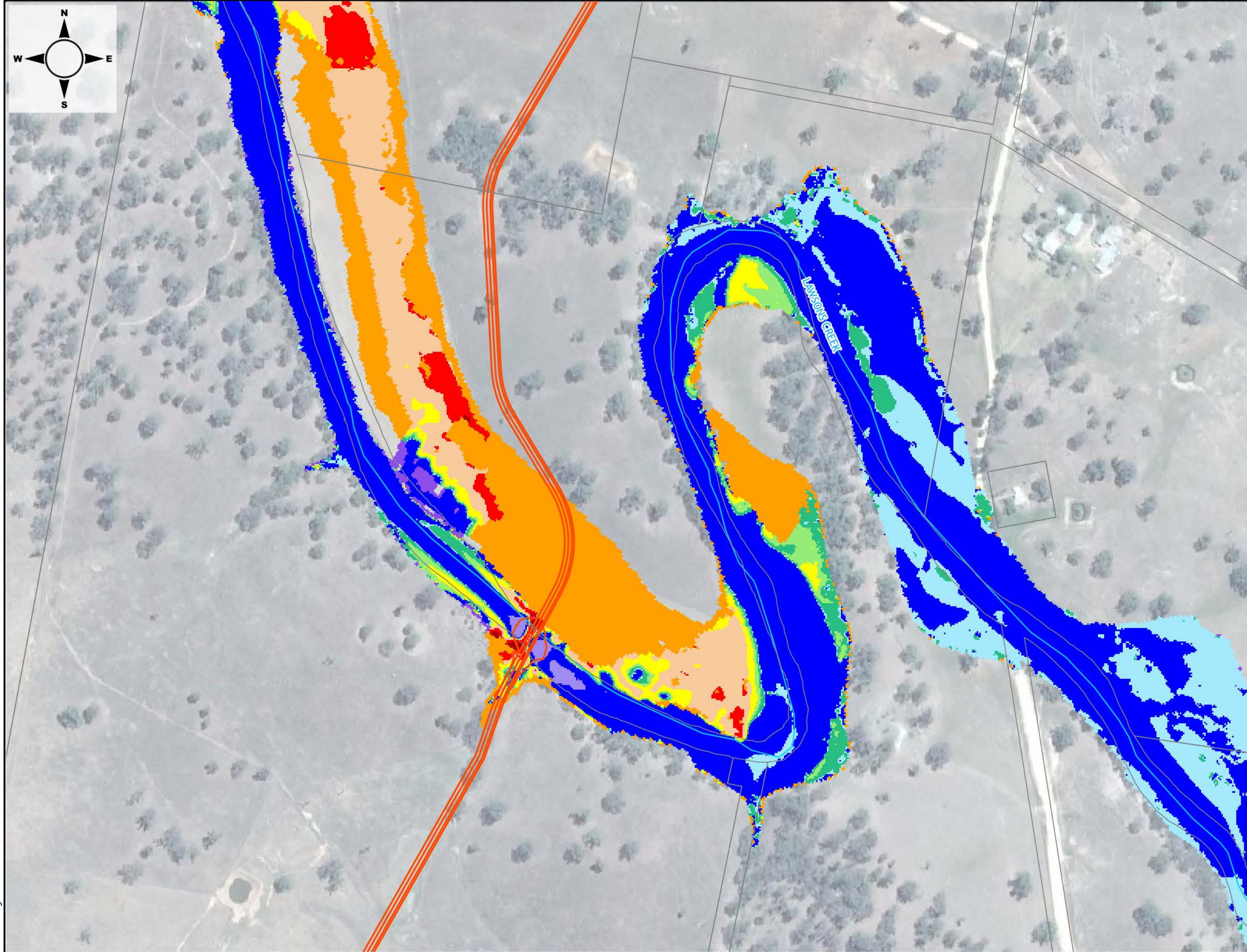
S
LAWSONS CREEK
Projection: MGA Zone 55   Datum: GDA 94
Legend
Major watercourse
Cadastre
Proposed infrastructure
Change in peak water level
< -1.00 m
-1.00 m to -0.01 m
-0.01 m to 0.01 m
0.01 m to 0.05 m
0.05 m to 0.10 m
0.10 m to 0.50 m
0.50 m to 1.00 m
1.00 m to 2.00 m
2.00 m to 3.00 m
3.00 m to 5.00 m
> 5.00 m
Was wet now dry
Was dry now wet
0
100
200 m
Bowdens Silver Project
Change in Peak Water Level, 0.2% AEP, Maloneys Rd relocation
wrm
water + environment



Bowdens Silver Project

Change in Peak Velocity, 10% AEP, Maloneys Rd relocation

wrm water + environment



Legend

- Major watercourse
- Cadastre
- Proposed infrastructure

Change in velocity

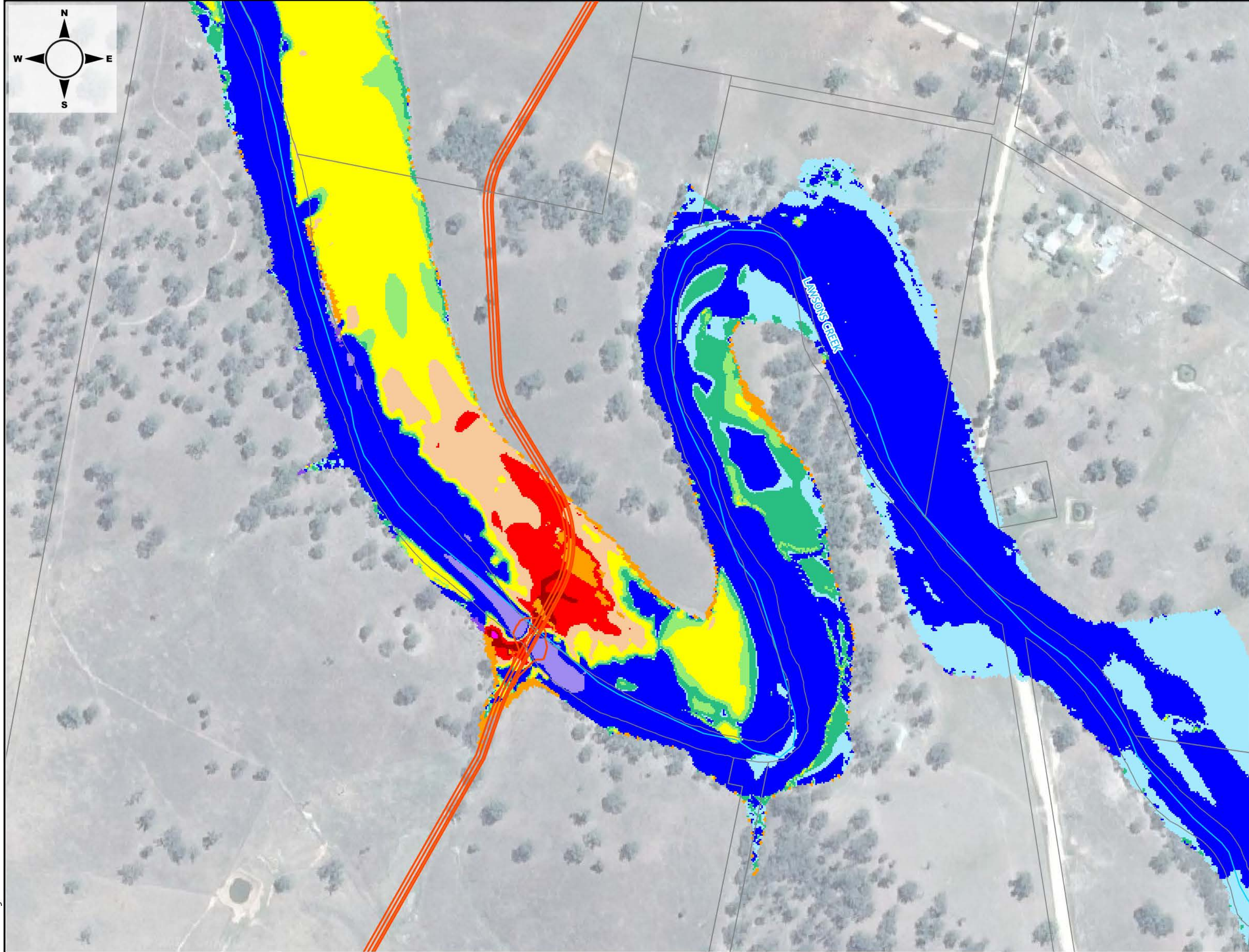
- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s
- Was wet now dry
- Was dry now wet

0 100 200 m

Bowdens Silver Project

Change in Peak Velocity,
5% AEP, Maloneys Rd relocation

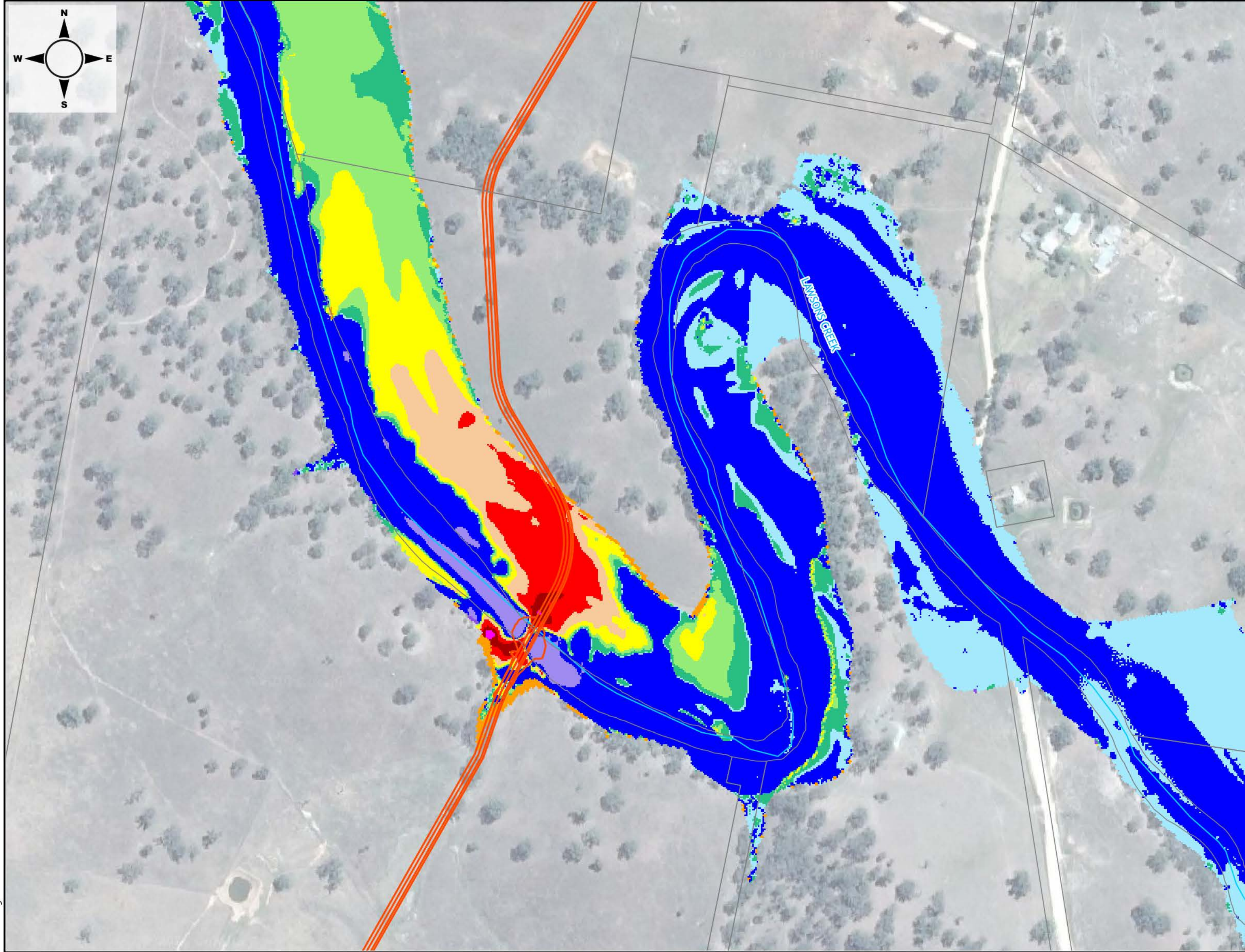
wrm water + environment



Bowdens Silver Project

Change in Peak Velocity, 2% AEP, Maloneys Rd relocation

wrm water + environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

Major watercourse
Cadastre
Proposed infrastructure

Change in velocity

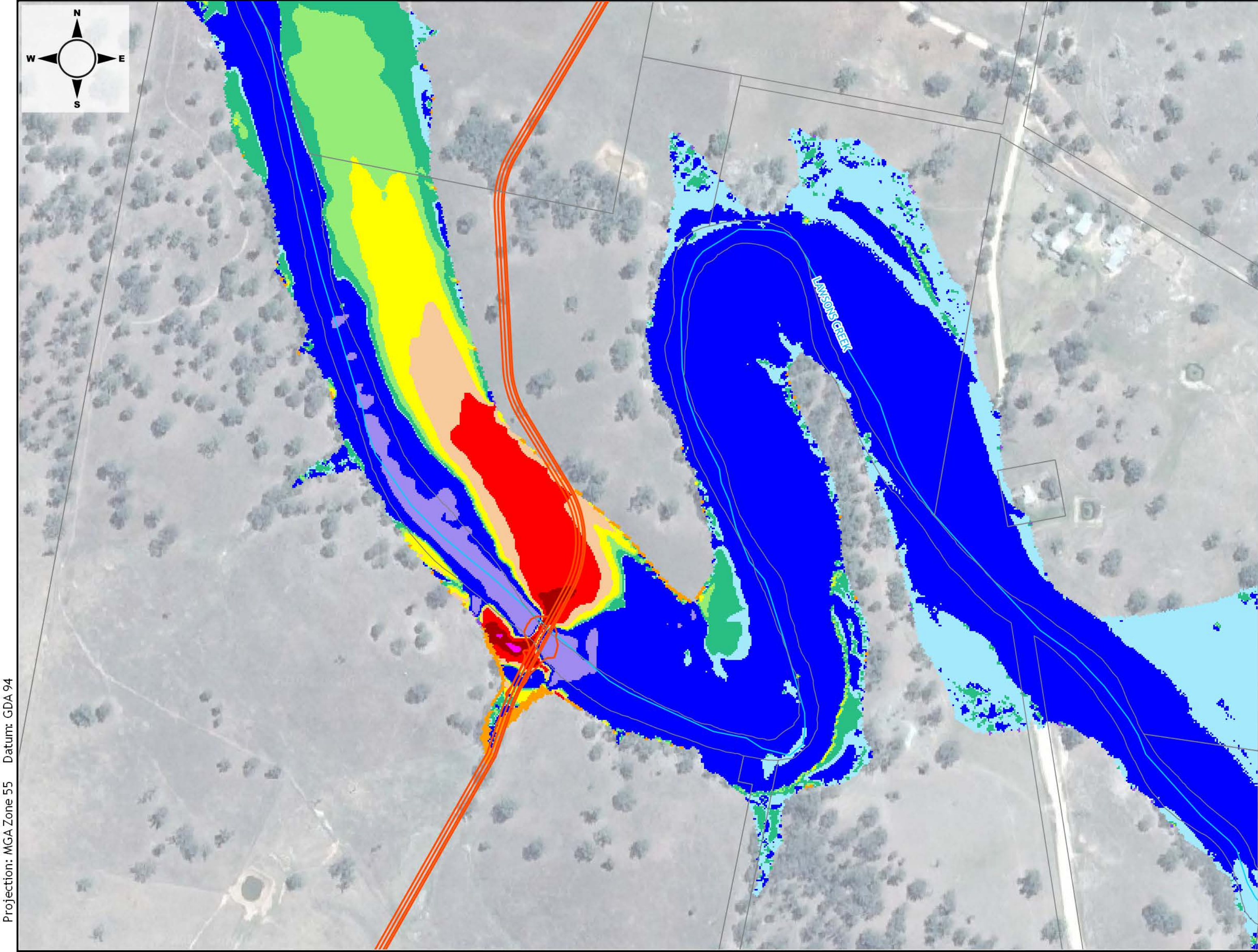
- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s
- Was wet now dry
- Was dry now wet

0 100 200 m

Bowdens Silver Project

Change in Peak Velocity,
1% AEP, Maloneys Rd relocation

wrm water + environment



Legend

- Major watercourse
- Cadastre
- Proposed infrastructure

Change in velocity

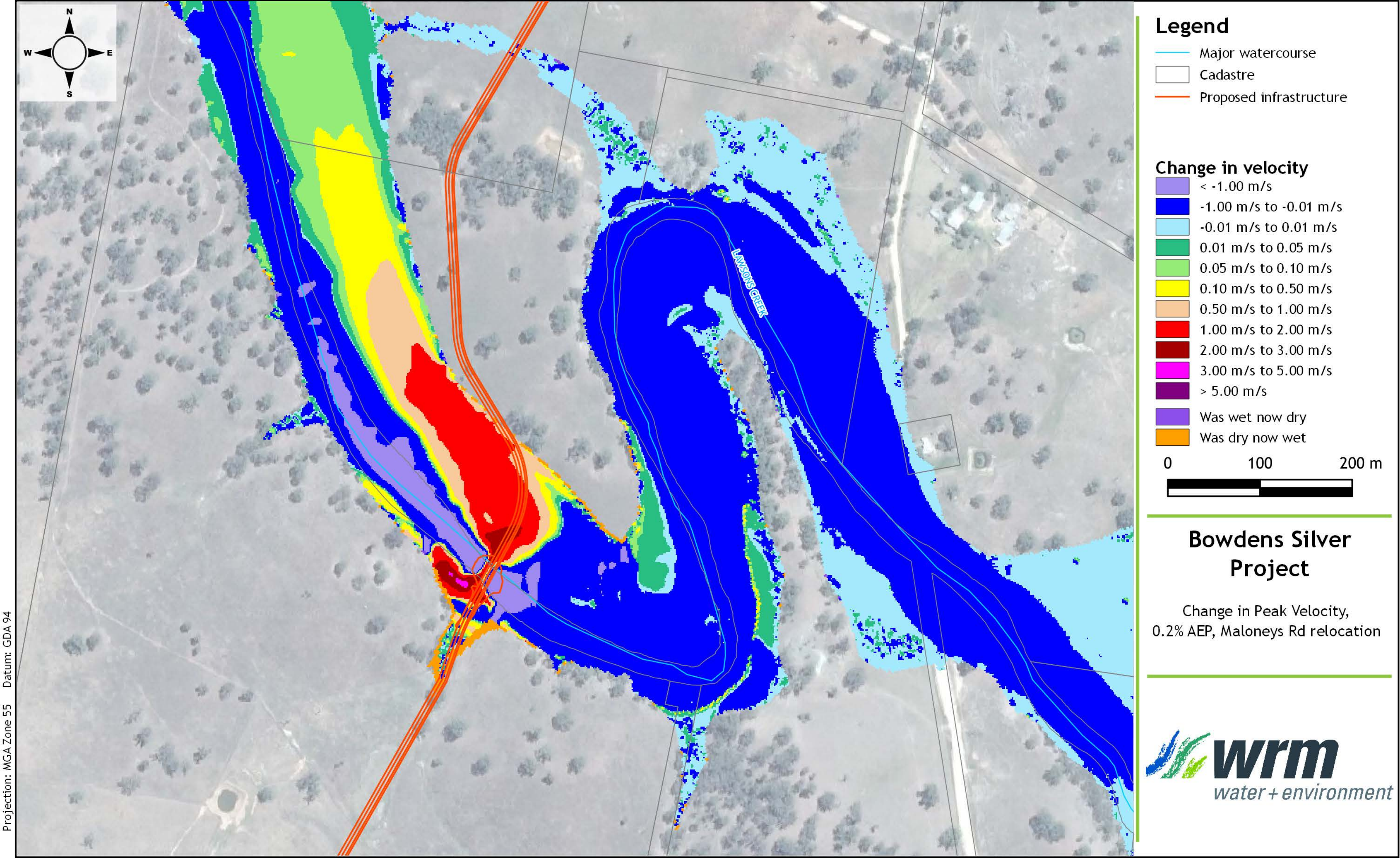
- < -1.00 m/s
- -1.00 m/s to -0.01 m/s
- -0.01 m/s to 0.01 m/s
- 0.01 m/s to 0.05 m/s
- 0.05 m/s to 0.10 m/s
- 0.10 m/s to 0.50 m/s
- 0.50 m/s to 1.00 m/s
- 1.00 m/s to 2.00 m/s
- 2.00 m/s to 3.00 m/s
- 3.00 m/s to 5.00 m/s
- > 5.00 m/s
- Was wet now dry
- Was dry now wet

0 100 200 m

Bowdens Silver Project

Change in Peak Velocity,
0.5% AEP, Maloneys Rd relocation

wrm water + environment


N
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LAWSONS CREEK
Datum: GDA 94
Projection: MGA Zone 55
Legend
Major watercourse
Cadastre
Proposed infrastructure
Change in velocity
< -1.00 m/s
-1.00 m/s to -0.01 m/s
-0.01 m/s to 0.01 m/s
0.01 m/s to 0.05 m/s
0.05 m/s to 0.10 m/s
0.10 m/s to 0.50 m/s
0.50 m/s to 1.00 m/s
1.00 m/s to 2.00 m/s
2.00 m/s to 3.00 m/s
3.00 m/s to 5.00 m/s
> 5.00 m/s
Was wet now dry
Was dry now wet
0
100
200 m
Bowdens Silver Project
Change in Peak Velocity, 0.2% AEP, Maloneys Rd relocation
wrm
water + environment

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Annexure C

Peer Review

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HYDRO ENGINEERING & CONSULTING PTY LTD

26 February 2020

Principal Environmental Consultant
RW Corkery & Co Pty Limited
PO Box 239
BROOKLYN NSW 2083
Attention: Nick Warren

Nick,

Re: Bowdens Silver Project EIS – Surface Water Assessment Peer Review

I have reviewed and commented on the Surface Water Assessment (SWA) for the Bowdens Silver Project (the Project) Environmental Impact Statement (EIS) prepared by WRM Water & Environment Pty Ltd (WRM) including the Annexure A Water Course Assessment by RW Corkery & Co Pty Limited and the Annexure B Flood Impact Assessment by WRM. This included multiple reviews of the SWA report. The review related mainly to the text and numerical content of the SWA and the two annexures, however a brief review was also undertaken of WRM's calibration of the catchment AWBM (rainfall-runoff model) for the Cudgegong River Upstream of Rylstone.

In undertaking the review I have checked that the SWA addresses the surface water resources related Secretary's Environmental Assessment Requirements (SEARs). These are summarised in Section 2 of the SWA report (although it was noted that multiple versions of the SEARs appear to exist).

Through the peer review process I have made a number of requests for clarification and suggestions for modifications to the methodology and reporting. The main suggestions related to the following issues.

- The veracity of calibration of the AWBM for the Cudgegong River Upstream of Rylstone and the appropriateness of AWBM parameter values for the Project water balance model.
- Revision of monitored baseline water quality statistics (Annexure A).
- Management of runoff and seepage from non-acid forming (NAF) waste rock emplacement areas, including enlarged sediment dam storage capacities and contingency pump-back measures, depending on the results of on-going testwork and monitoring.
- Increased detail on and verification of the feasibility of diversion of runoff around proposed satellite pits.

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Rosalie QLD 4064
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Carindale QLD 4152
www.hecons.com
ABN 11 247 282 058

- Increased detail on management and modelling of runoff and seepage from potentially acid forming waste rock emplacement areas.
- Clarification of the quantity and salinity of water to be imported to the Project.
- Additional water balance model sensitivity analyses (relating to groundwater inflow rates).
- Revision of process plant makeup priority such that water collected from the waste rock emplacement leachate management dam is used as a first priority.
- Use of contemporary design loss rates for hydrologic modelling undertaken to estimate design flood flow rates (Annexure B).

The majority of these were resolved to my satisfaction. It is concluded that the assessment as it stands is sufficient and fit for purpose for the EIS, in terms of the assessment of surface water-related impacts as it has:

- adequately described the existing surface water environment in the vicinity of the Project and the relevant environmental values;
- developed and described a proposed comprehensive water management system and demonstrated through modelling that such a system is predicted to operate adequately under a range of climatic scenarios; and
- assessed the potential impacts on relevant environmental values due to the development of the Project.

During the review of the project water balance modelling it was noted that a number of assumptions and considerations were made (with justification), however it is recommended that further analysis be conducted during subsequent studies or detailed design to refine the design of the water management infrastructure. In summary, the recommendations for further analysis are as follows:

- continued geochemical testing and characterisation of runoff and seepage from NAF waste rock emplacement areas to guide determination of sediment dam sizing and the need for pump back to the water management system;
- consideration should be given to amending hydrologic (flood) modelling where justified using the most up to date recommended design loss parameters for NSW for higher annual exceedance probabilities (2% and higher) – as noted in Section 5.6.3 of Annexure A; and
- further refinement of modelled natural catchment AWBM parameters using site monitored flow data if possible.

Notwithstanding the above, this further analysis is considered unlikely to significantly affect the modelling outcomes/conclusions and therefore assessment of potential impacts already described in the Surface Water Assessment.

Please contact the undersigned if you require further information.

Yours faithfully,

Tony Marszalek
Director

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