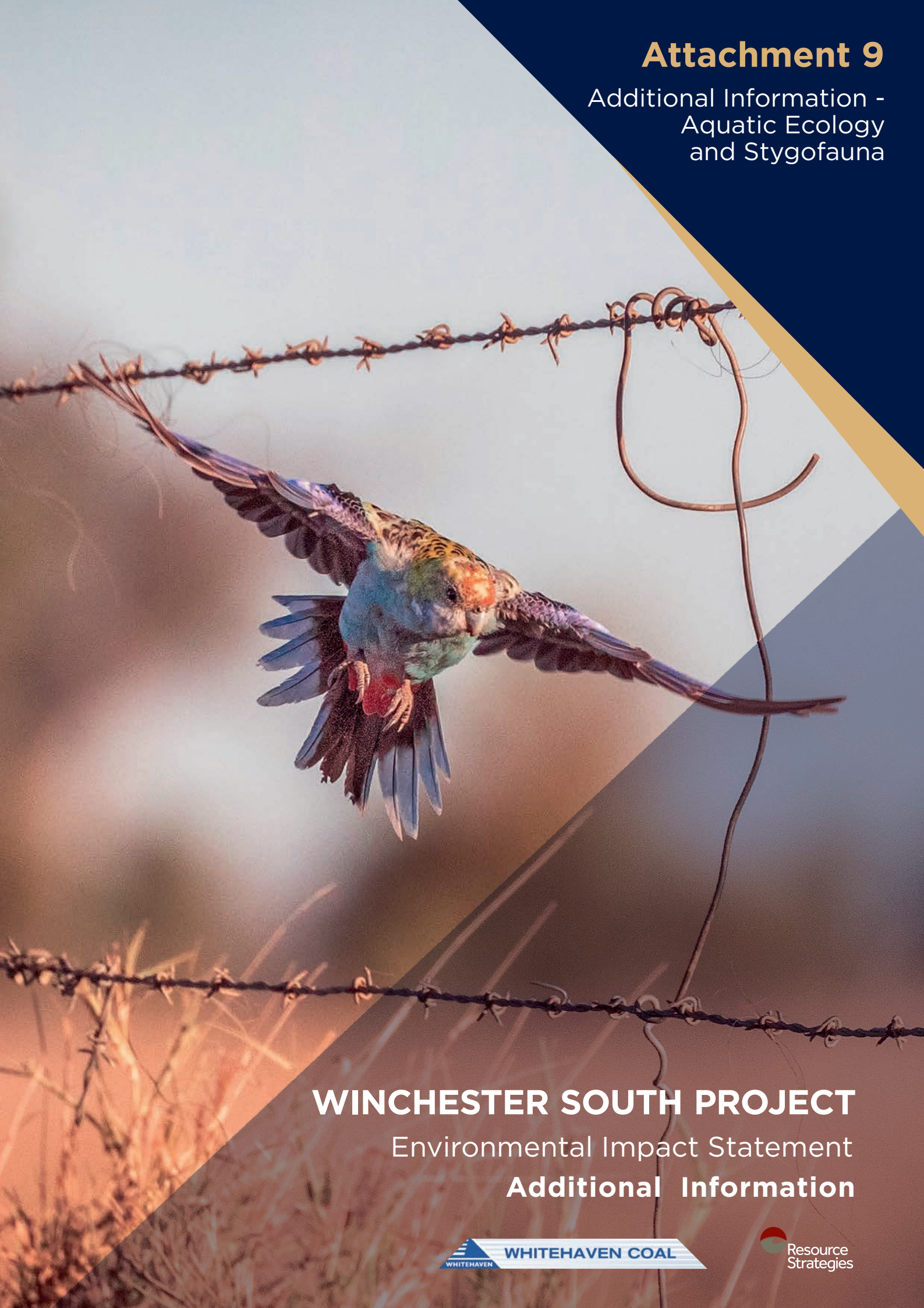
Attachment 9

Additional Information - Aquatic Ecology and Stygofauna



WINCHESTER SOUTH PROJECT

Environmental Impact Statement

Additional Information

WHITEHAVEN COAL

Resource Strategies

Winchester South Project EIS

Aquatic Ecology and Stygofauna, Additional Information

Prepared for: Whitehaven WS Pty Ltd

Prepared by Ecological Service Professionals Pty Ltd

July 2022

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Executive Summary

Introduction and Scope of Assessment

This report has been prepared for Whitehaven WS Pty Ltd (Whitehaven WS), a wholly owned subsidiary of Whitehaven Coal Limited. Whitehaven WS propose to develop the Winchester South Project (the Project), an open cut coal mine and associated infrastructure within the Bowen Basin, located approximately 30 kilometres (km) south-east of Moranbah, within the Isaac Regional Council Local Government Area. Ecological Service Professionals (ESP) completed the aquatic ecology and stygofauna assessment for the Draft Environmental Impact Statement (Draft EIS) for the Project. The Draft EIS has been publicly notified, and the Coordinator General has requested additional information for the EIS.

This report provides additional information with respect to aquatic ecology and stygofauna, in response to comments from the relevant agencies including the Queensland Department of Agriculture and Fisheries (DAF), Fisheries Queensland Division and the Commonwealth's Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC). Specifically, it provides:

- a waterway determination of waterways providing for fish passage within the study area, based on a desktop review of previous waterways assessments and a detailed supplementary field survey
- an assessment of fish communities to inform the waterway determination, based on a desktop review of previous assessments in the vicinity of the Project, and results from a wet-season supplementary field survey, and
- an assessment of stygofauna communities as informed by a desktop review and results from supplementary stygofauna sampling at bores targeting regolith and the Isaac River alluvium.

Methods

The Project area comprises the surface disturbance extent within the Project mining lease application area (MLA). The study area includes the waterways, farm dams and wetlands upstream of, adjacent to, within, and downstream (i.e. in the receiving environment) of the Project area, including the Isaac River and its tributaries.

For the assessment of waterways providing for fish passage, a comprehensive desktop review was undertaken of the previous aquatic ecology surveys and waterway assessments completed on the site in 2011/2012, 2019, 2020, and 2021, and the aquatic ecology surveys for the adjacent Olive Downs Project completed in 2016/2017. To verify and supplement the results of the desktop review, an additional field survey was completed in the wet season (February 2022). Survey sites for the waterway determination included waterways and farm dams within, upstream and downstream of the Project area. Survey methods involved aquatic habitat assessments at 85 sites on waterways mapped on the DAF Waterways for Waterway Barrier Works (WWBW) spatial layer, supplemented with fish surveys at three sites (using a combination of seine and fyke netting, and baited box trapping).

Stygofauna sampling was completed at six bores distributed within the regolith and alluvium. Each bore was established at least six months prior to stygofauna sampling and contained groundwater. In-situ water quality measurements for electrical conductivity (EC) and pH were also taken at each bore, to aid in the interpretation of results.

Results

Aquatic habitats in waterways and dams within the study area were typical of ephemeral systems in the broader region. At the time of the February 2022 assessment all waterway features were dry, with no standing water. Most of the assessed dams contained water.

Our waterway assessment found large sections of the three unnamed waterway features mapped on the DAF WWBW spatial layer lacked the features required to be considered a waterway, as defined by the *Fisheries Act 1994* (Fisheries Act). Here, waterway assessments consistently indicated that the mapped features:

- lacked continuously defined bed and banks
- had no aquatic vegetation other than in discrete patches within water-holding dams
- contained significant barriers for fish passage in the form of raised dam walls (for dams that have been in place for many years) with steep slopes, quarry walls and rock barriers, and road crossings
- lacked fish habitat, other than within the water-holding dams, and
- appeared to have insufficient flow or water availability to sustain basic aquatic ecological processes and habitats.

Sections of waterway exhibiting the qualities of a waterway providing for fish passage as defined by DAF were identified within the MLA on the northern and central unnamed waterways. The northern unnamed waterway contained 4.5 km of waterway providing for fish passage, with 1.52 km (constituting 2.45 hectares [ha]) within the Project proposed surface disturbance extent. The central unnamed waterway contained 3.54 km of waterway providing for fish passage, of which all would be outside the Project's proposed surface disturbance extent. Regarding a 'waterway providing for fish passage', the *Environmental Offsets Regulation 2014* (EO Regulation) states that any part of a waterway providing for passage of fish is a Matter of State Environmental Significance (MSES) only if the construction, installation or modification of waterway barrier works carried out under an authority will limit the passage of fish along the waterway. Therefore, only the northern unnamed waterway is a MSES relevant to the Project.

Most dams surveyed provided fish habitat opportunities. Fish from a range of life-history stages, including adults, intermediates, and juveniles, were captured during the February 2022 fish surveys. One pest fish species, Mozambique tilapia (*Oreochromis mossambicus*), was also recorded. Connectivity to downstream reaches of dams was limited by high dam walls, which act to limit fish passage opportunities except for periods of high flow when dams would overtop dam overflows. The fish survey results confirmed our waterway assessment and recommended mapping changes.

Two stygofauna taxa were recorded from a single bore targeting the Isaac River alluvium. This result is consistent with conclusions from the Draft EIS (ESP 2021), which concluded that stygofauna were likely to occur in areas of the alluvium along the Isaac River and lower

reaches of its larger tributaries. The groundwater assessment undertaken for the Draft EIS and supplementary analysis completed by SLR (2022) concluded that the Project is unlikely to impact the Isaac River alluvium.

1 Introduction

This report has been prepared by Ecological Service Professionals (ESP) for Whitehaven WS Pty Ltd (Whitehaven WS), a wholly owned subsidiary of Whitehaven Coal Limited. ESP completed the aquatic ecology and stygofauna assessment for the Draft Environmental Impact Statement (Draft EIS) for the Winchester South Project (the Project). The Draft EIS has been publicly notified, and the Coordinator General has requested additional information for the EIS.

1.1 Scope of Works

This report provides additional survey information with respect to aquatic ecology and stygofauna, in response to comments from the relevant agencies including the Queensland Department of Agriculture and Fisheries (DAF), Fisheries Queensland Division and the Commonwealth's Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC).

A separate Aquatic Ecology and Stygofauna Supplementary Assessment has been prepared by ESP in consideration of the additional information presented in this report, and the Optimised Project mine design.

2 Methods

2.1 Waterways Providing for Fish Passage

2.1.1 Waterway Determination

2.1.1.1 Desktop Review of Existing Information

A desktop review of available mapping resources and previous waterway assessments was undertaken, to assess waterway characteristics for tributaries within the Project area and adjacent properties upstream and downstream. The desktop review included an assessment of:

- the DAF Waterways for Waterway Barrier Works (WWBW) spatial layer (DAF 2020)
- the Queensland Department of Regional Development, Manufacturing and Water (DRDMW) watercourse mapping and *Watercourse Identification Map* (WIM) spatial layer (DRDMW 2022)
- the Queensland Department of Environment and Science (DES) wetland mapping spatial layer (DES 2019)
- connectivity of the mapped feature on the site through interpretation of current and historical aerial photography and topographical information, and
- existing material and reports, including:
    - *Winchester South Project, Environmental Impact Statement, Appendix E, Aquatic Ecology and Stygofauna Assessment* (ESP 2021)
    - *Winchester South Project, Aquatic Ecology Baseline Study* (frc environmental 2012)
    - *Olive Downs Coking Coal Project, Aquatic Ecology Assessment* (DPM Envirosciences 2018)
    - geomorphology assessment for the Project (Fluvial Systems 2020)
    - site photos from Whitehaven (Whitehaven WS 2021), and
    - assessment by DAF based on review of information and site photographs provided by Whitehaven WS from August and September 2021.

To assess the potential value of the mapped feature as a waterway offering fish habitat and fish passage, particular attention was given to whether the mapped feature met the definition of a waterway used by DAF under the *Fisheries Act 1994* (Fisheries Act). A waterway as defined by DAF (2022) must have at least one of the following:

- defined bed and banks:
    - bed and banks need to be continuous upstream and downstream of the site rather than isolated and broken sections of a depression.

- an extended (if not permanent) period of flow:
    - flow must continue beyond the duration of a rain event and have some reliability attached to rainfall. There is a need to distinguish between channels that funnel immediate localised rainfall and waterways where flow has arisen from an upstream catchment.
- adequate flow:
    - flow needs to be sufficient to sustain basic ecological processes and habitats, and to maintain biodiversity within or across the feature. The adequacy of the flow depends on the ecological function of the channel (e.g. waterways that connect to fish habitat like a wetland or waterhole may only need infrequent and short-duration flows to provide connectivity for fish).
- fish habitat at, or upstream of, the site:
    - most instream features (submerged logs, overhanging vegetation) provide habitat for fish under adequate flow conditions or, in the case of pools, during dry periods. Periodic connectivity to upstream and off stream fish habitat are also considered fish habitat.

The Fisheries Act defines a waterway as a river, creek, stream, watercourse, drainage feature or inlet of the sea, with the definition of a 'drainage feature' being consistent with that provided in paragraph (b) of the *Water Act 2000* for a 'drainage feature', which includes:

(b) a natural landscape feature, including a gully, drain, drainage depression or other erosion feature that—

(i) is formed by the concentration of, or operates to confine or concentrate, overland flow water during and immediately after rainfall events; and

(ii) flows for only a short duration after a rainfall event, regardless of the frequency of flow events; and

(iii) commonly, does not have enough continuing flow to create a riverine environment.

Furthermore, regarding a 'waterway providing for fish passage', the *Environmental Offsets Regulation 2014* (EO Regulation) states that any part of a waterway providing for passage of fish is a Matter of State Environmental Significance (MSES) only if the construction, installation or modification of waterway barrier works carried out under an authority will limit the passage of fish along the waterway. Clause 10 of Schedule 2 of the EO Regulation further defines 'passage' for fish as the natural movement patterns of fish species required to maintain the biological integrity of the species, and 'waterway' as a river, creek, stream, watercourse or inlet of the sea, and therefore, does not include drainage features.

Representative photographs and a detailed commentary from the desktop assessment are provided in Appendix A.

2.1.1.2 Supplementary Waterway Surveys

Supplementary site surveys were undertaken from 23 to 28 February 2022 by Senior Ecologists Dr Matthew Hayes and Dr Paul Tompkins to qualitatively (visually) assess the waterway and fish passage values of the three unnamed waterways within the study area. This involved collecting observations and records (including photographs) of habitat features, including presence of continuous beds and banks, and type of aquatic flora and fauna (if visible) along each of the mapped features, including locations upstream and downstream of the Project MLA (Figure 2.2 to Figure 2.5).

There was 8.6 millimetres (mm) of rain recorded over two days during the survey (24–25 February; assessed from nearby BOM Station No. 34035). February rainfall prior to the survey was 3.6 mm. Rainfall in the previous month (97.2 mm) was above average for January (92.5 mm, based on available data from 2013 through to 2022; BOM Station No. 34035).

To assess the potential value of each mapped feature as a waterway offering fish habitat and fish passage, particular attention was given to whether the mapped feature met the definition of a waterway used by DAF under the Fisheries Act (as summarised above in Section 2.1.1.1).

Other data collected at each verification site included:

- GPS locations for each site
- photographs of upstream, downstream, and left and right banks
- a measurement of main channel width, bankfull width, and low flow channel width, and
- a brief description of the observed waterway features.

Appendix 3 of the *Accepted development requirements for operational work that is constructing or raising waterway barrier works* (Accepted Development Requirements) (DAF 2018) provides guidance on what constitutes the main channel.

The following definitions are provided in the Accepted Development Requirements (as illustrated in Figure 2.1):

- **Bankfull width** is the width of the waterway at the bankfull level.
- **Main channel** is the active component of the flow channel characterised by a distinct change in appearance or structure at the upper limit of the channel such as undercutting, changes in vegetation density, sudden changes in bank slope, boundary levels for water marks, mosses or lichens, changes in sediment particle size. Approximate Q values of Q1–Q2 or AEP equivalent. Where the main channel width is variable, use an average width for the site.

Representative photographs and the detailed results of the supplementary waterway field assessment are provided in Appendix B.

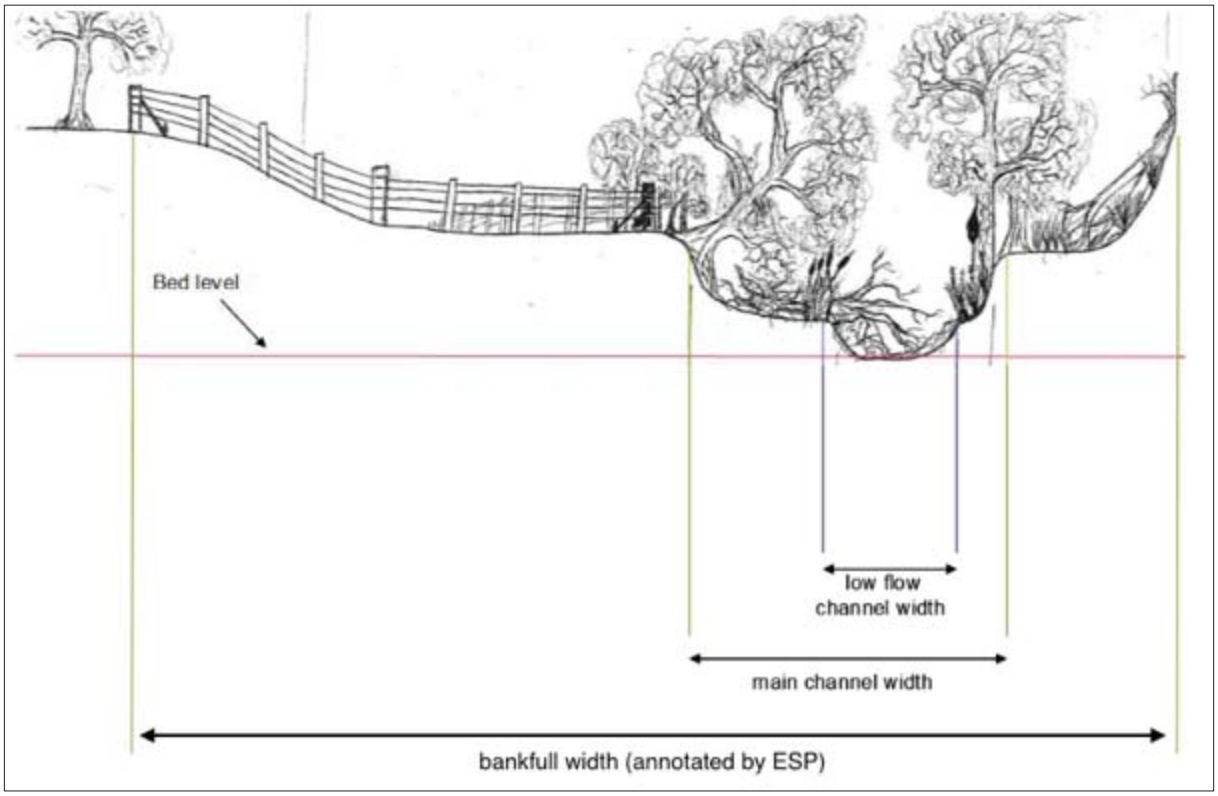


Figure 2.1 Example of waterway cross section showing main channel, low channel and bankfull width (adapted from DAF 2018)

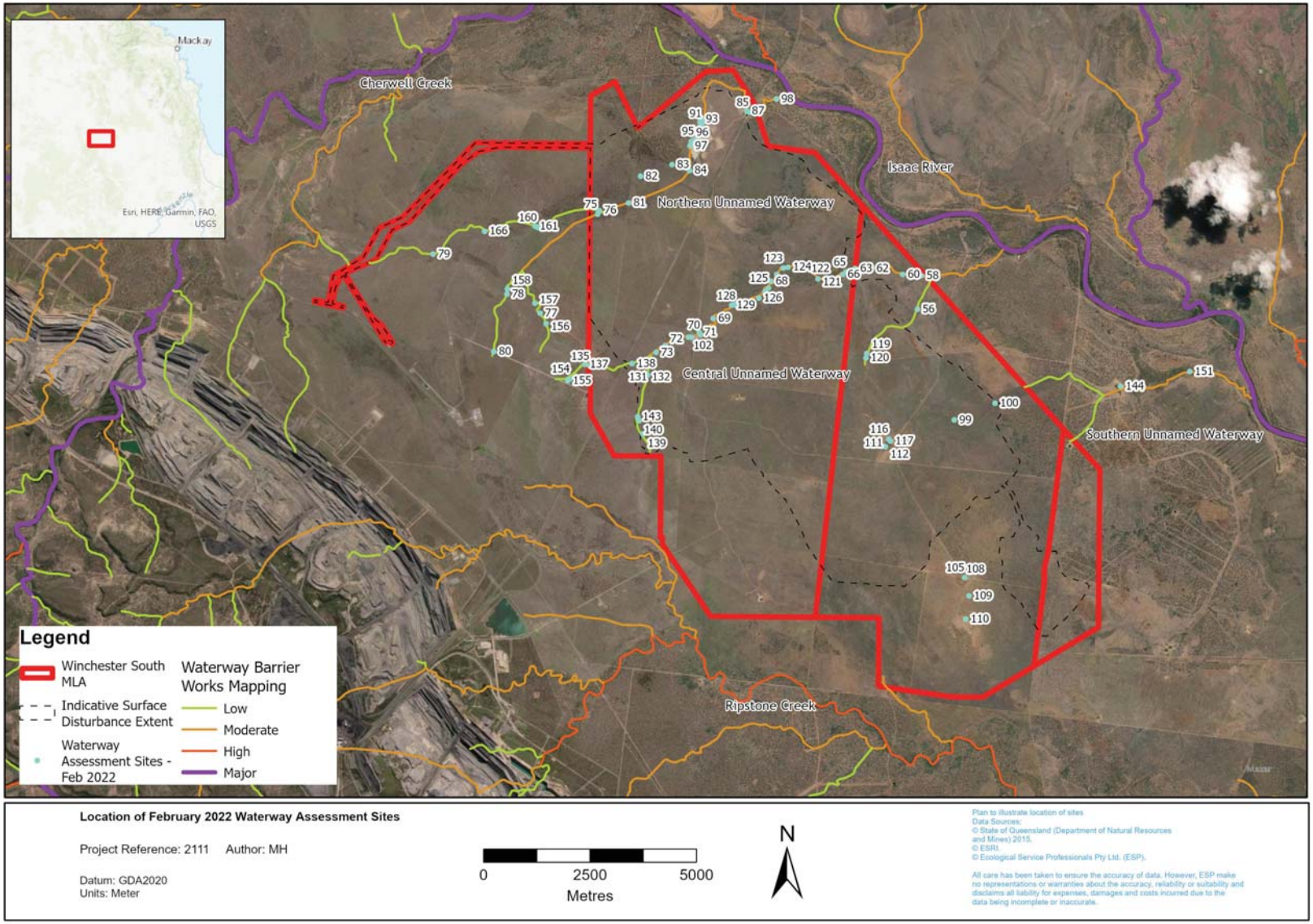


Figure 2.2 Waterway assessment sites surveyed by ESP in February 2022

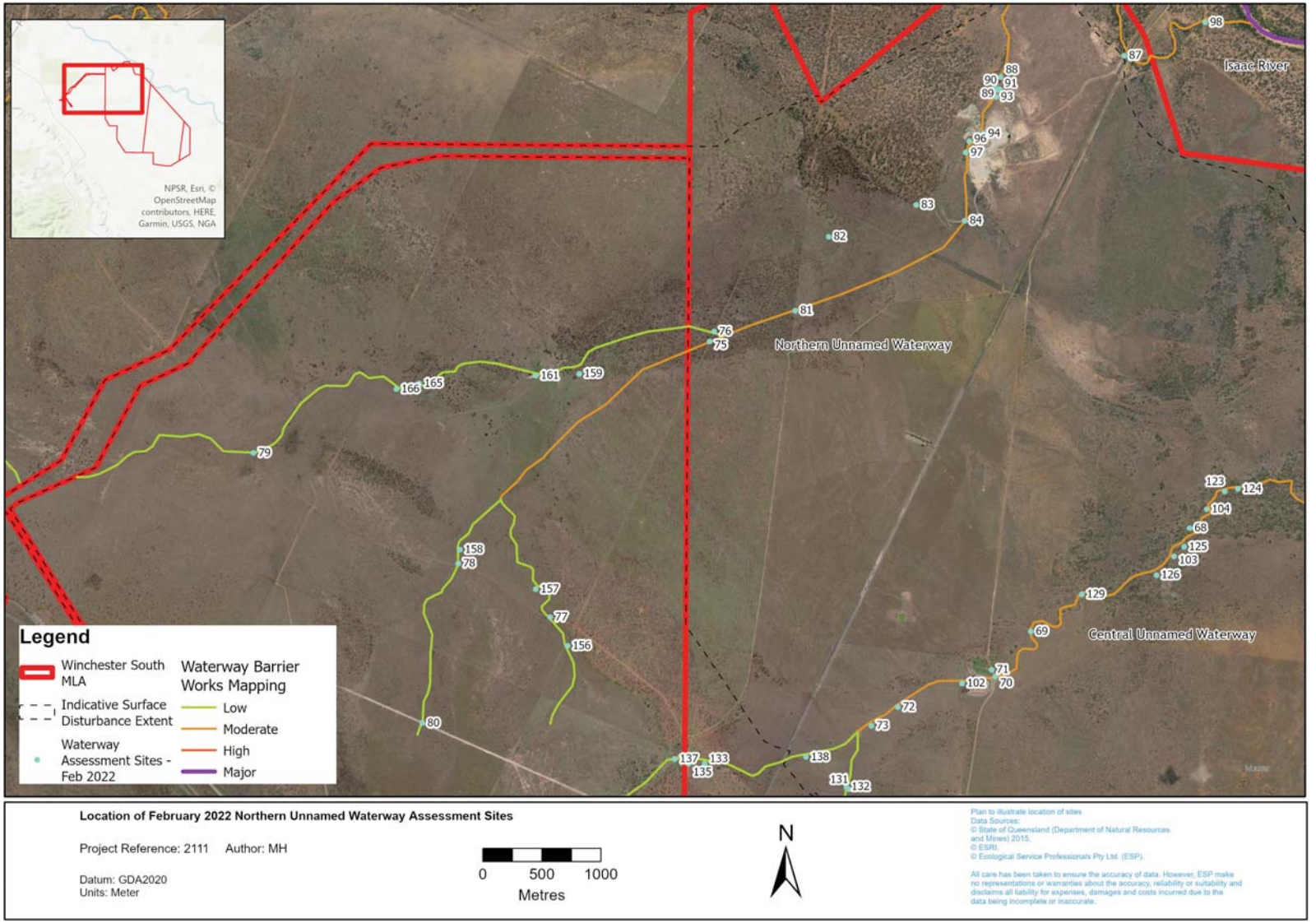


Figure 2.3 Waterway assessment sites along the northern unnamed waterway, surveyed by ESP in February 2022

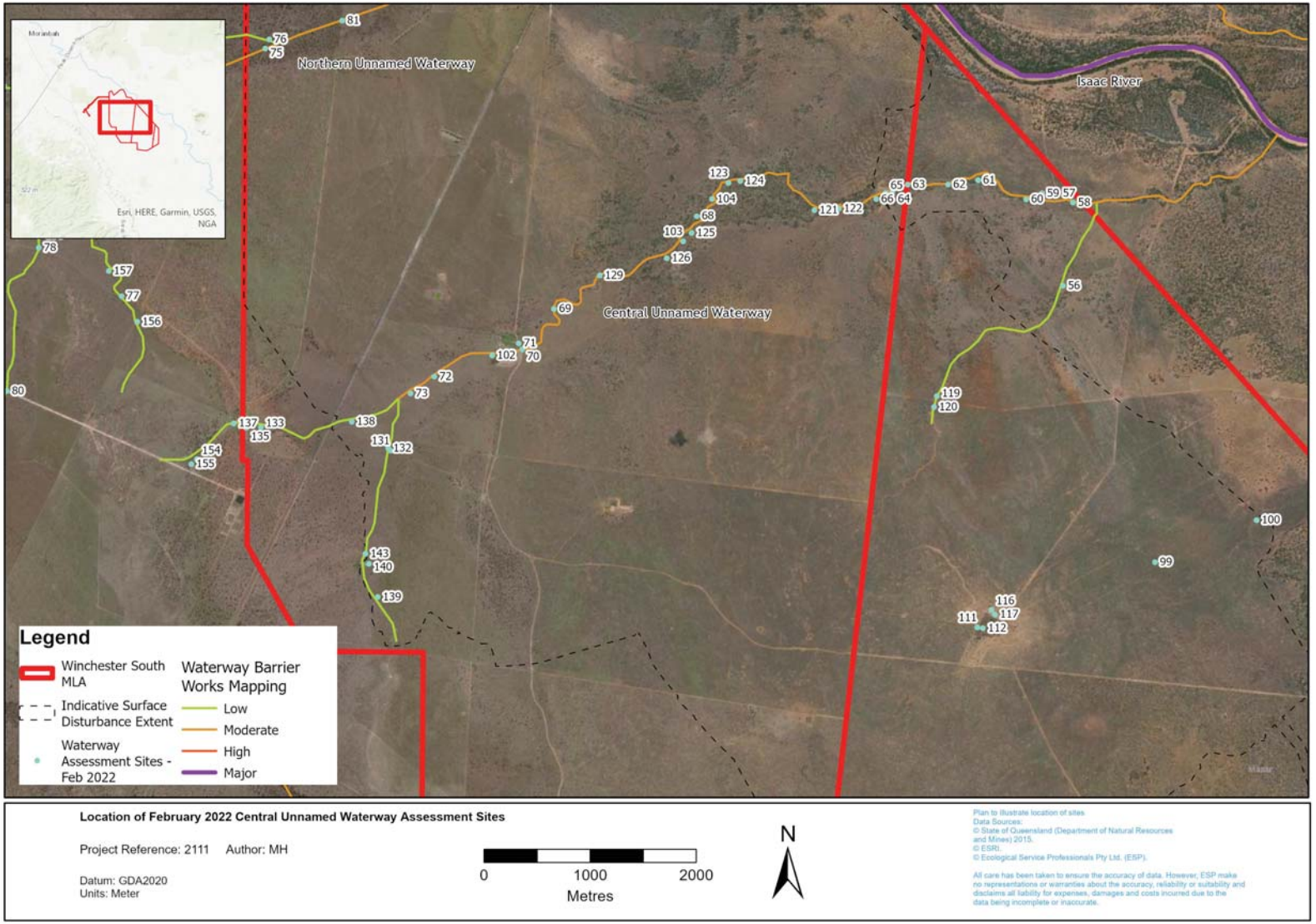


Figure 2.4 Waterway assessment sites along the central unnamed waterway, surveyed by ESP In February 2022

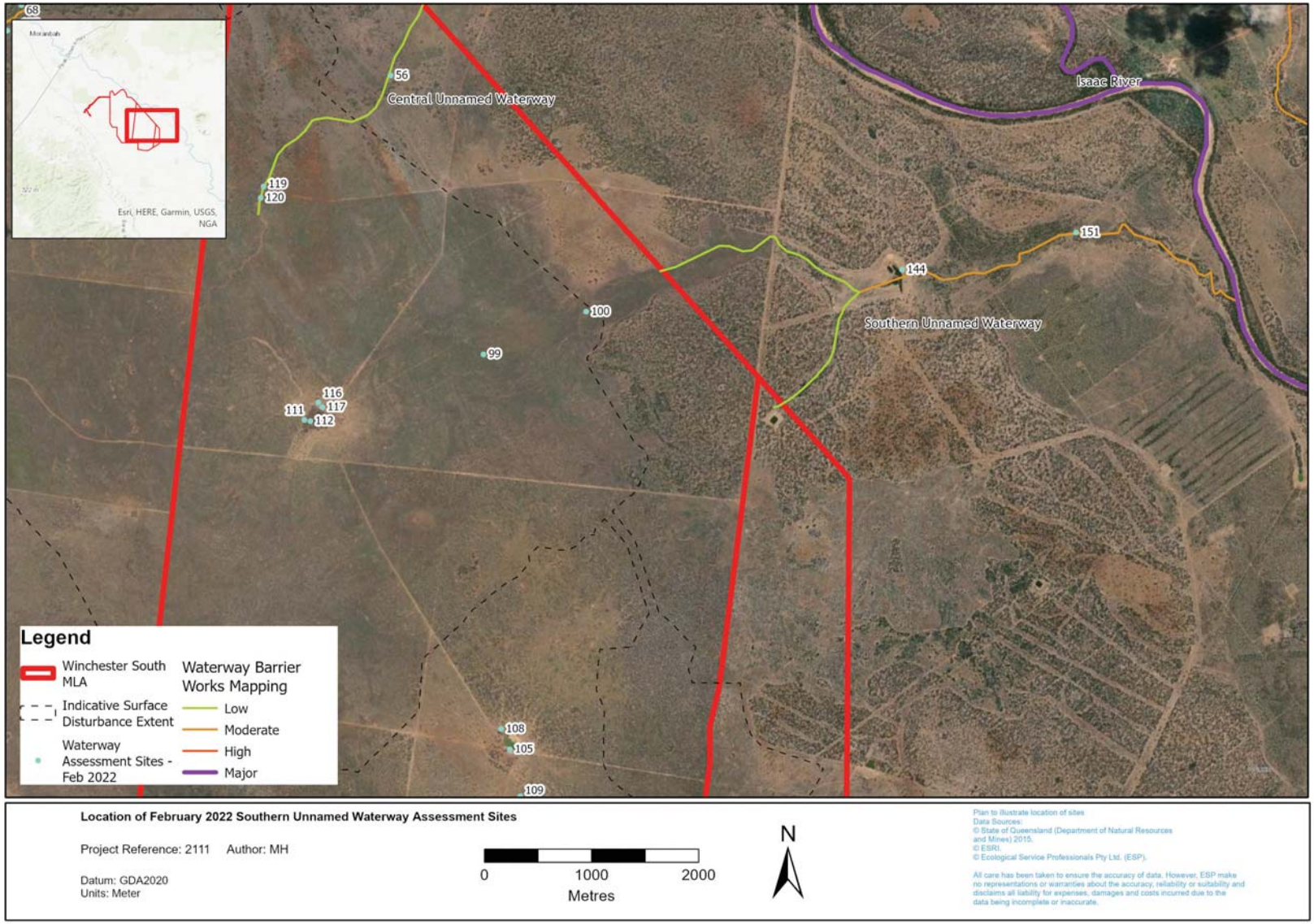


Figure 2.5 Waterway assessment sites along the southern unnamed waterway, surveyed by ESP in February 2022

2.1.2 Fish Communities

2.1.2.1 Desktop Review of Existing Information

A review of available fish survey data within the Project area and the adjacent reaches of the Isaac River was performed to assess fish community composition. Our review included:

- *Winchester South Project, Environmental Impact Statement. Appendix E, Aquatic Ecology and Stygofauna Assessment*, Ecological Service Professionals (ESP 2021)
- *Winchester South Project, Aquatic Ecology Baseline Study* (frc environmental 2012), and
- *Olive Downs Coking Coal Project, Aquatic Ecology Assessment* (DPM Enviros ciences 2018).

Previous fish survey site locations are shown on Figure 2.6.

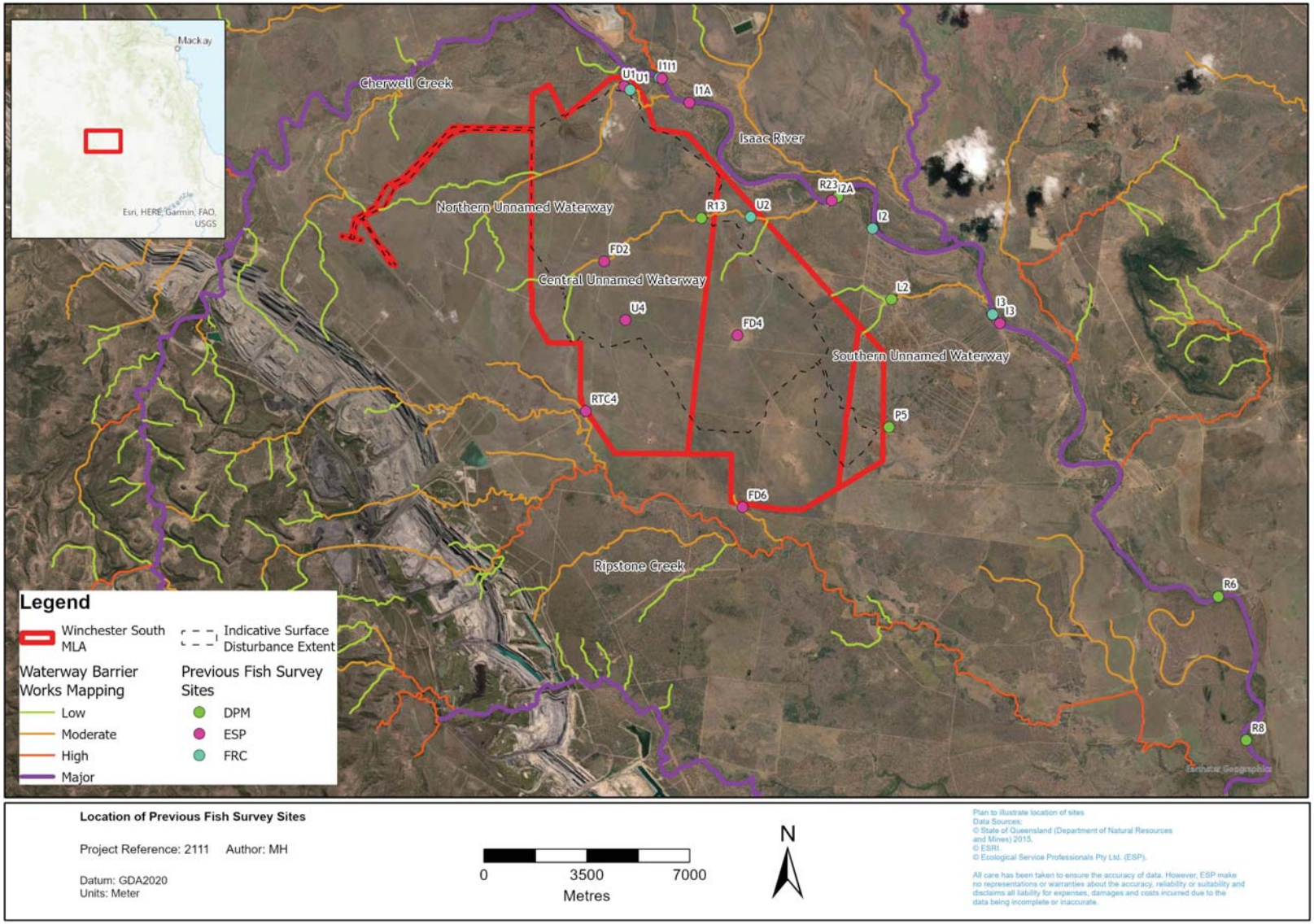


Figure 2.6 Locations of previous fish survey sites

2.1.2.2 Supplementary Fish Surveys

Supplementary fish surveys were completed in conjunction with the waterway assessments described above at three additional locations along the northern unnamed waterway, including a large dam located within the area of the onsite quarry, and two semi-permanent pools located upstream and downstream of the large dam (Figure 2.7). The fish surveys were completed using a combination of methods depending on the habitat characteristics of the site, including baited traps, fyke netting and seine netting. Sampling efforts were concentrated around preferred fish habitats such as instream vegetation and structures. Survey details including location, fishing method and effort were recorded and are summarised in Table 2.1.

Captured fish were transferred into a bucket containing ambient site water and fitted with an aerator to ensure adequate oxygenation. Fish were identified and counted, and the first 20 individuals of each species were measured (total length), before being returned to the water. One representative of each species was photographed.

All sampling was completed in accordance with the *Monitoring and Sampling Manual 2018* (DES 2018), and covered under relevant permits issued to ESP, including:

- Queensland General Fisheries Permit 208641
- Queensland Scientific Purposes Permit WA0017831
- Queensland Scientific User Registration Number SUR000532, and
- Queensland Animal Ethics Permit CA 2020/06/1378.

Table 2.1 Fish survey effort per site

Site	Gear Type	Number	Start Time and Date	End Time and Date	Total Effort
QS1	Box traps	3	16:30, 26/2/2022	07:30, 27/2/2022	45
Q1	Box traps	5	17:00, 26/2/2022	08:30, 27/2/2022	77.5
	Fyke nets	2	17:00, 26/2/2022	08:30, 27/2/2022	31
QN1	Seine	1	15:00, 28/2/2022	15:10, 28/2/2022	1 Sweep

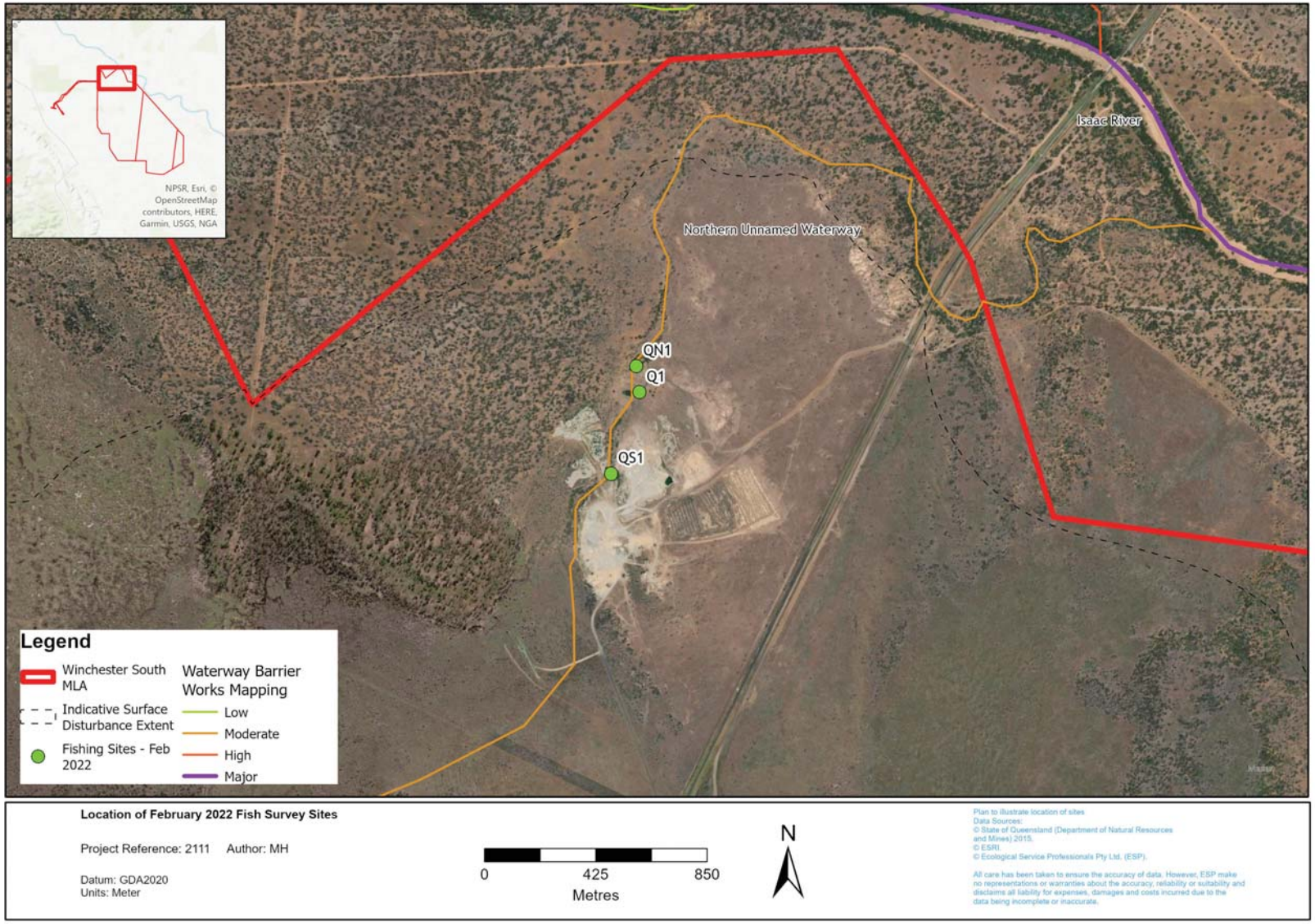


Figure 2.7 Location of February 2022 fish survey sites

2.2 Stygofauna

2.2.1 Desktop Review of Existing Information

A summary of available stygofauna data within the Project area and the adjacent reaches of the Isaac River was completed. Our review included:

- *Winchester South Project, Environmental Impact Statement. Appendix E, Aquatic Ecology and Stygofauna Assessment*, Ecological Service Professionals (ESP 2021)
- *Olive Downs Coking Coal Project, Environmental Impact Statement* (DPM Enviros ciences 2018)
- *Moorvale South Coal Project* (pers. comms. Peabody Pty Ltd 2022)
- *Isaac Downs Project, Environmental Impact Statement* (frc environmental 2019), and
- *Vulcan Complex Project, Environmental Impact Statement* (frc environmental 2020).

2.2.2 Supplementary Stygofauna Surveys

Supplementary stygofauna surveys were completed in February 2022, as per the *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DES 2015). Sampling was completed at six bores, distributed within the regolith and Isaac River alluvium. Each bore was established at least six months prior to stygofauna sampling and contained groundwater. The locations of the bores sampled are described in Table 2.2 and displayed on Figure 2.8.

Water quality (conductivity and pH) was measured in-situ at each bore using a hand-held YSI ProDSS multi-parameter water quality sonde, calibrated prior to field sampling. A bailer was used to collect a water sample from approximately 1–2 metres (m) below the water level of the bore. The sample was retrieved slowly and poured into the measuring cup of the water quality probe.

The full water column within each bore was sampled by hauling a weighted phraetobiological net. Three hauls were completed with a fine mesh net (50 micrometres [µm]), and three hauls were completed with a coarse mesh net (150 µm). Nets were lowered to the bottom of the bore, bounced five times to dislodge resting animals and then carefully retrieved. After each haul, the net and collection vial were emptied onto a 50 µm sieve and rinsed with deionised water. The three fine mesh hauls and three coarse net hauls were combined into one sample per bore and preserved in 100% ethanol. Nets were rinsed thoroughly with deionised water between survey bores.

Photographs were taken of the bore and surrounding environment during all surveys. The diameter of the bore, casing type, whether the bore was screened and whether a pump was installed, the height of the collar and the depth of the bore and depth to water level were also recorded.

The methods and equipment used to sample stygofauna complied with standards in accordance with the *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DES 2015).

The stygofauna samples were sorted in the laboratory under a stereomicroscope. Each sample container was drained of ethanol and washed into a shallow elongated counting tray to create a thin layer of sediment spread across the bottom of the tray. Any animals were transferred into 2 millilitres vials with 100% ethanol and identified to the lowest practical taxonomic level.

Stygofauna or potential stygofauna taxa recorded in the samples were sent to Dr Peter Hancock (Eco Logical Australia) for identification to the lowest practical taxonomic level (family).

Table 2.2 Bore sampling sites surveyed in May and October 2019, January 2020, and February 2022 for the Winchester South EIS

Bore	Aquifer	Latitude	Longitude	Total Depth (mbGL)	May-19	Oct-19	Jan-20	Feb-22
Wynette Bore	Alluvium	-22.1497	148.3071	18.6[a]	–	Y	Y	Y
Knob Hill 2	Alluvium	-22.1136	148.2645	23.4[a]	–	Y	Y	Y
C2136	Alluvium	-22.1750	148.2778	65.6	Y	–	Y	–
R2009	Alluvium	-22.2151	148.2740	81.0	Y	–	Y	–
R2010	Alluvium	-22.2128	148.2782	64.5	Y	–	Y	–
R2032	Alluvium	-22.1877	148.2658	81.1	Y	–	Y	–
R2035	Alluvium	-22.1946	148.2532	37.4	Y	–	Y	–
R2054	Alluvium	-22.1674	148.2535	82.5	Y	–	Y	–
R2055	Alluvium	-22.1697	148.2492	67.9	Y	–	Y	–
Knob Hill 1	Alluvium	-22.1152	148.2701	20.0[a]	–	–	Y	–
R2008	Alluvium	-22.2173	148.2698	33.0	–	–	Y	–
MB3	Regolith	-22.1510	148.2339	45.0	–	–	–	Y
IF3860P	Alluvium	-22.1823	148.3807	15.0	–	–	–	Y
IF3862P	Alluvium	-22.1779	148.3731	18.0	–	–	–	Y
IF3839P	Alluvium	-22.1749	148.2155	20.0	–	–	–	Y

mbGL = metres below ground level

– not sampled

Y sampled

[a] field estimate, data not available

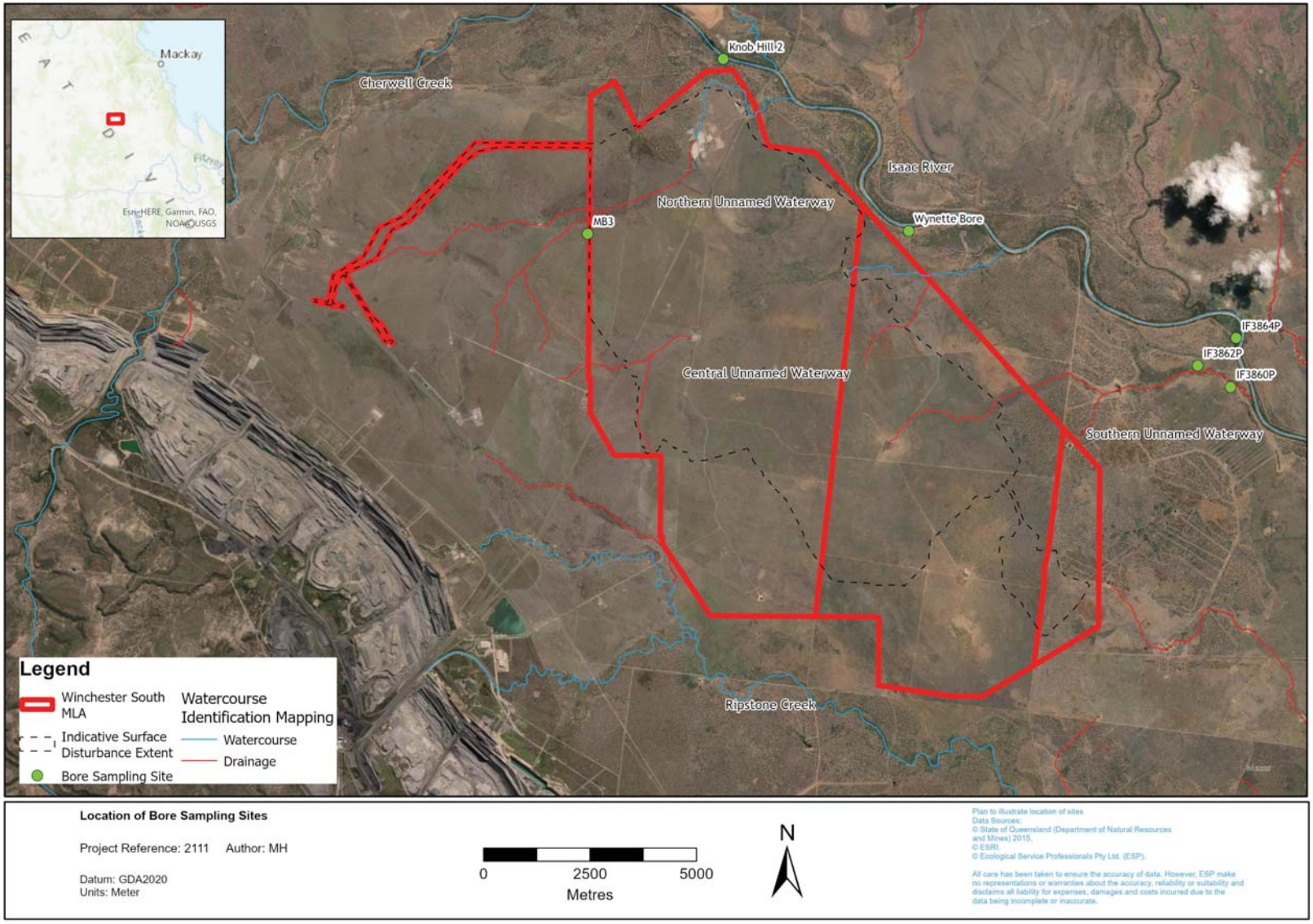


Figure 2.8 Location of bores surveyed for stygofauna in February 2022

3 Waterways Providing for Fish Passage

3.1 Waterway Determination

3.1.1 Desktop Review of State Government Mapping

3.1.1.1 Northern Unnamed Waterway

The northern unnamed waterway is currently mapped as an amber (moderate risk of impact) and green (low risk of impact) waterway on the DAF WWBW spatial layer (Figure 2.2). The mapped feature initiates to the west of the Project MLA on Lot 8 SP277384 as three tributaries mapped as green waterways. The three tributaries flow into the Project MLA in a north-east direction, where they join into a single amber waterway, before passing into Lot 15 CNS111. It then flows in an easterly direction, eventually joining the Isaac River, a mapped purple (major risk of impact) waterway on the DAF WWBW spatial layer, approximately 1.2 km downstream of the Project MLA.

The northern unnamed waterway is mapped as a drainage feature and a watercourse on the DRDMW WIM spatial layer (Figure 3.1). The mapped feature initiates as a drainage feature to the west of the Project MLA on Lot 8 SP277384. The mapped feature passes into the Project MLA as a drainage feature, where the mapping changes from a drainage feature to a watercourse at the former quarry, before passing into Lot 15 CNS11i.

The mapped feature is a minor feature on the DES wetland mapping spatial layer (Figure 3.2). The mapped feature is present on the Queensland topographic map, where it is mapped as a drain or channel (Figure 3.3).

3.1.1.2 Central Unnamed Waterway

The central unnamed waterway is currently mapped as an amber (moderate risk of impact) and green (low risk of impact) waterway on the DAF WWBW spatial layer (Figure 2.2). The mapped feature initiates as two green mapped tributaries, with one of the tributaries initiating to the west of the Project MLA on Lot 8 SP277384, and the other within the MLA boundary. The two tributaries converge within the MLA where the mapped feature changes to an amber waterway, passing through the MLA in an easterly direction. The mapped feature then passes into Lot 4 CNS15, before joining the Isaac River approximately 2.2 km downstream of the Project MLA.

The central unnamed waterway is mapped as two separate sections of waterway on the DRDMW WIM spatial layer (Figure 3.1). The most westerly section is mapped as a drainage feature. The most easterly section is mapped as a watercourse that initiates in the approximate location of the proposed disturbance boundary and flows into the Isaac River. A small tributary, mapped as a drainage feature, joins the watercourse at the boundary of the Project MLA, before the confluence with the Isaac River.

The central unnamed waterway is mapped as a minor feature on the DES wetland mapping spatial layer (Figure 3.2). The mapped feature is present on the Queensland topographic map, where it is mapped as a drain or channel (Figure 3.3).

3.1.1.3 Southern Unnamed Waterway

The southern unnamed waterway is currently mapped as an amber (moderate risk of impact) and green (low risk of impact) waterway on the DAF WWBW spatial layer (Figure 2.2). The mapped feature initiates as two green mapped tributaries within the Winchester South MLA. The two tributaries exit the Project MLA in an easterly direction into Lot 11 KL135, where they converge into a single feature mapped as an amber waterway, before joining the Isaac River approximately 5.5 km downstream of the MLA.

The southern unnamed waterway is mapped as a drainage feature on the DRDMW WIM spatial layer (Figure 3.1) and as a minor feature on the DES wetland mapping spatial layer (Figure 3.2). The mapped feature is present on the Queensland topographic map, where it is mapped as a drain or channel (Figure 3.3).

The northern tributary of the southern unnamed waterway initiates approximately 4.2 km further upstream in the DRDMW WIM spatial layer (as a drainage feature), the DES wetland mapping spatial layer, and the Queensland topographic mapping, when compared with the DAF WWBW spatial layer mapping.

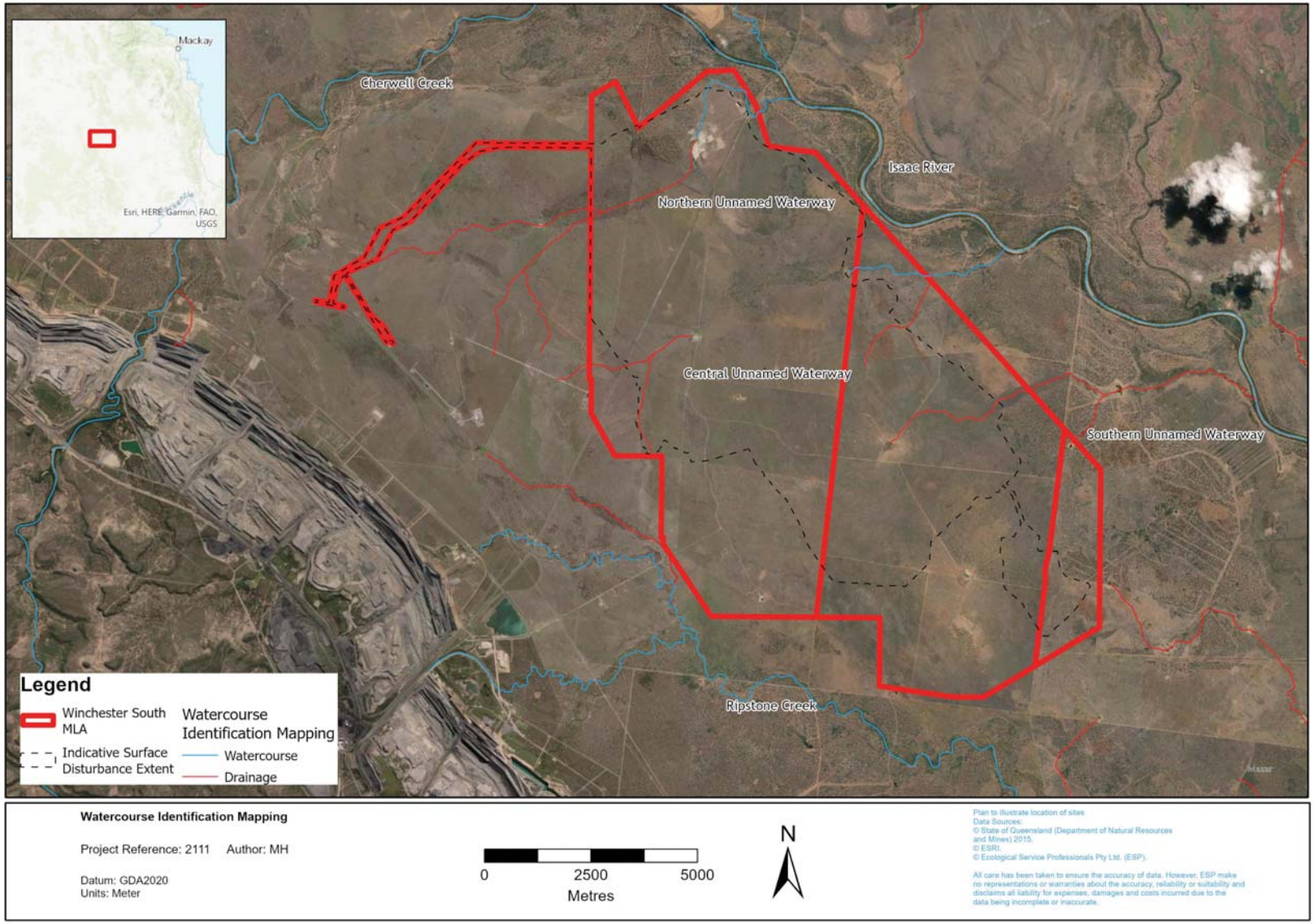


Figure 3.1 Watercourse identification mapping

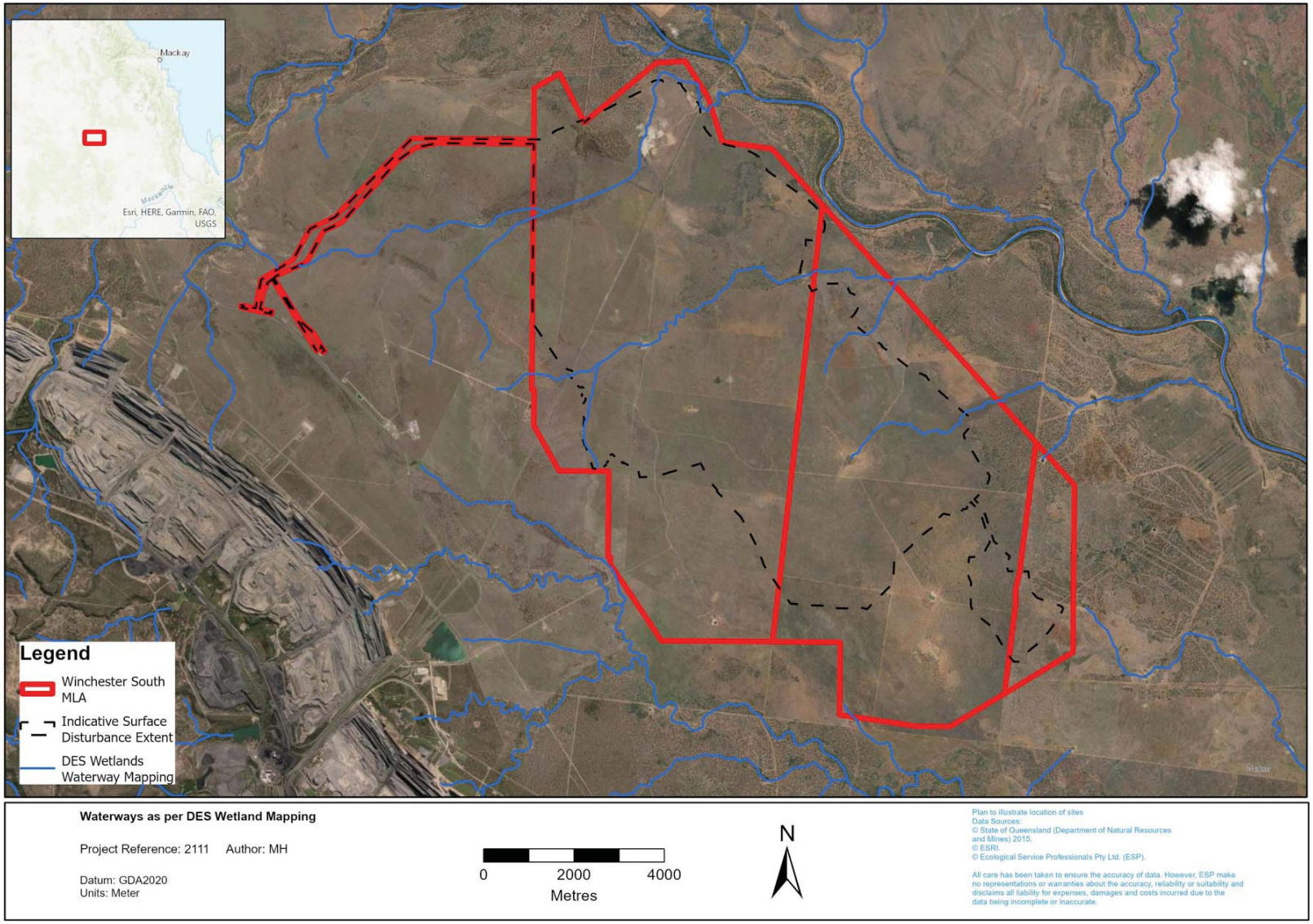


Figure 3.2 Waterways as per DES wetland mapping

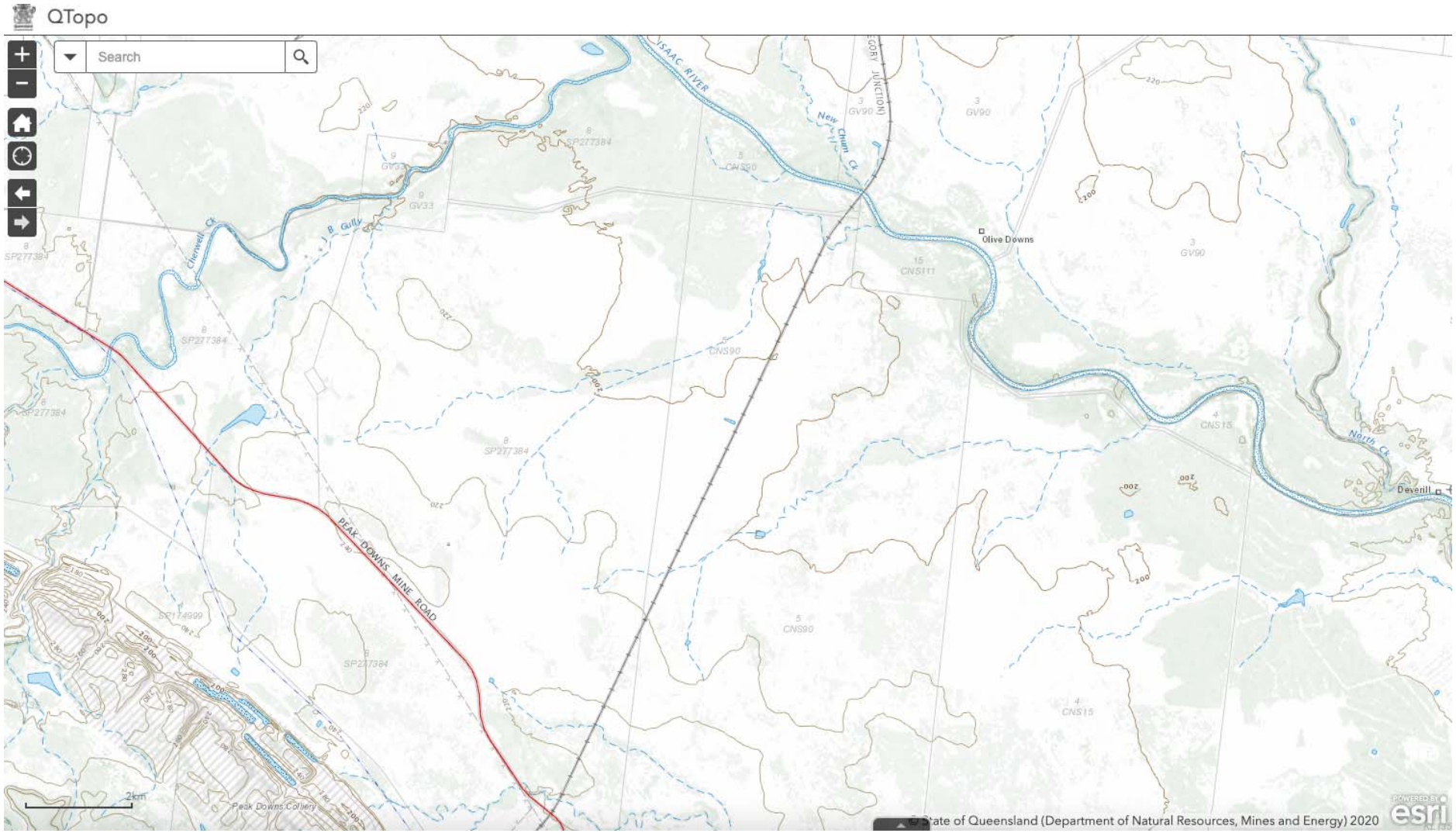


Figure 3.3 Queensland topographic map for the area surrounding the mapped feature (QTopo 2020)

3.1.2 Desktop Review of Previous Surveys

Representative photographs and a detailed commentary from the desktop assessment are provided in Appendix A.

3.1.2.1 Survey Timing and Rainfall Conditions

Rainfall conditions prior to and during each of the waterway assessments previously completed as part of the Project are summarised in the sub-sections below, with sites assessed shown on Figure 3.4.

Aquatic Ecology Baseline Surveys (2011 & 2012)

In September 2012, frc environmental prepared an aquatic ecology baseline study report (frc environmental 2012) of Mineral Development Licence (MDL) 183 and waterways in the immediate surroundings. Two seasonal surveys were undertaken: one in the early-wet season (28 November to 29 November 2011) and one in the post-wet season (30 April to 1 May 2012). The two sites assessed on the unnamed waterways included Site U1 (corresponding with Site U1 assessed by ESP in 2019 as shown on Figure 3.4) and Site U2 (i.e. corresponding with Site U2 assessed by ESP in 2019 and Site B8 assessed during the geomorphology assessment in 2019, as shown on Figure 3.4).

Conditions during the early-wet season survey were dry (< 20 mm rain for the month of November at the nearby Iffley station), although a total of approximately 17 mm of rain had been recorded over the three days prior to the survey. Temperature data for the Moranbah region are not available for the period of this survey, however at the nearest weather station (Clermont Airport) temperatures ranged from 19.1 to 35.5 degrees Celsius (°C). Conditions during the post-wet season survey were also relatively dry with < 35 mm rain falling within the month prior to the survey at the Moranbah Airport station. However, the month of March (one month prior to the survey) had seen approximately 200 mm of rain. Temperatures in the Moranbah region ranged from 10.7°C to 28.7°C during this survey.

Aquatic Ecology EIS Surveys (2019)

ESP completed two seasonal aquatic ecology surveys in 2019 as part of the Draft EIS for the Project (ESP 2021).

The late-wet season aquatic ecology survey was from 15 to 22 May 2019. The weather was dry and sunny with temperatures ranging from 12°C – 30°C. Rainfall in the months leading up to the survey was variable. The rainfall in January and February, which are typically the wettest months of the year, was lower than average (only 60 mm of rainfall recorded in January and less than 30 mm of rainfall recorded in February). However, significant rainfall was recorded in March, with 135 mm recorded between 17 and 30 March 2019, which is much higher than the monthly average for the region (97.7 mm from 2012 to 2019). Rainfall in the six weeks leading up to the survey was low, with less than 10 mm recorded in April and less than 5 mm recorded at the start of May.

While no flow was recorded upstream of the study area at Goonyella (station 130414A), flow was recorded at Deverill (station 130410A) immediately downstream of the Project; with minor flows recorded in November and December 2018 and significant flow recorded in March 2019, which reflect periods of rainfall.

The early-wet season aquatic ecology survey was from 14 to 22 October 2019. The weather was dry and sunny, with temperatures ranging from 15°C – 39°C and rainfall in the months prior to the survey was low. Rainfall between June and October was below the long-term average for the region, except in June when 25 mm was recorded. Some rain was recorded in the week leading up to the survey with 13 mm recorded between 11 and 12 October; however, this was not considered significant enough to alter the conditions on-site. Furthermore, no flow was recorded in the Isaac River upstream or downstream of the study area in the months leading up to the survey, which is reflective of the dry conditions.

Geomorphology Assessment (2019)

Assessments were completed from 19 to 21 November 2019 (Fluvial Systems 2020). No rain was recorded during the assessment (recorded at Moranbah Airport station, 34035). Rain was recorded in the weeks prior to the assessment, with 16.6 mm recorded. There was 13.4 mm of rain recorded in the month prior, which was lower than the long-term average (from 2012 to 2021) of 22 mm.

Winchester South Project Site Inspections (2021)

Site inspections were undertaken in August and September 2021 (Whitehaven WS 2021). There was 62.0 mm and 21.8 mm of rain recorded for August and September, respectively (recorded at Moranbah Airport station, 34035). There was 39 mm of rain recorded in July, the month prior. Prior to the assessments, the reported rainfall was higher than long-term averages of 29.1 mm, 14.3 mm and 9.7 mm for July, August and September, respectively.

Olive Downs EIS (2016 – 2017)

DPM Enviroscienses conducted aquatic habitat assessments and seasonal fish surveys as part of the EIS for the Olive Downs Project from 12 to 19 December 2016, 22 to 28 June 2017, 4 to 11 July 2017, 2 to 9 October 2017, and 14 to 20 November 2017.

There was 11.6 mm of rain on the first day of the December 2016 survey, and 110 mm of rain recorded over the two days prior (Moranbah Airport station, 34035). However, little rain was recorded prior to the three-day rain event, with only 42.2 mm of rain in November 2016 and 7.8 mm in October 2016. There was no rain recorded in the weeks prior to the June and July 2017 surveys. However, 101 mm of rain was recorded in the previous month in May 2017 (far exceeding the long-term average for May of 28.5 mm), and no rain recorded in April 2017.

There was 56 mm of rain recorded over the first two days of the October 2017 survey, however the prior two months of August and September had recorded only 1.2 and 0.4 mm of rain for the month respectively. 19.2 mm of rain was recorded over the final two days of the November 2017 survey. There was approximately 18.8 mm of rain in the two weeks of November prior to the survey, and 86 mm in the previous month.

DPM Enviroscienses reported no rain was recorded during the ‘late wet’ survey period, in June and July 2017, although surface water was prevalent as a result of significant rainfall and runoff associated with Cyclone Debbie in late March 2017. They reported the Isaac River was in flow at the time of the late wet season surveys, although the flow had reduced to scattered deep pools connected only by very shallow, trickling runs. Numerous wetlands and gilgais within their survey area remained full of water.

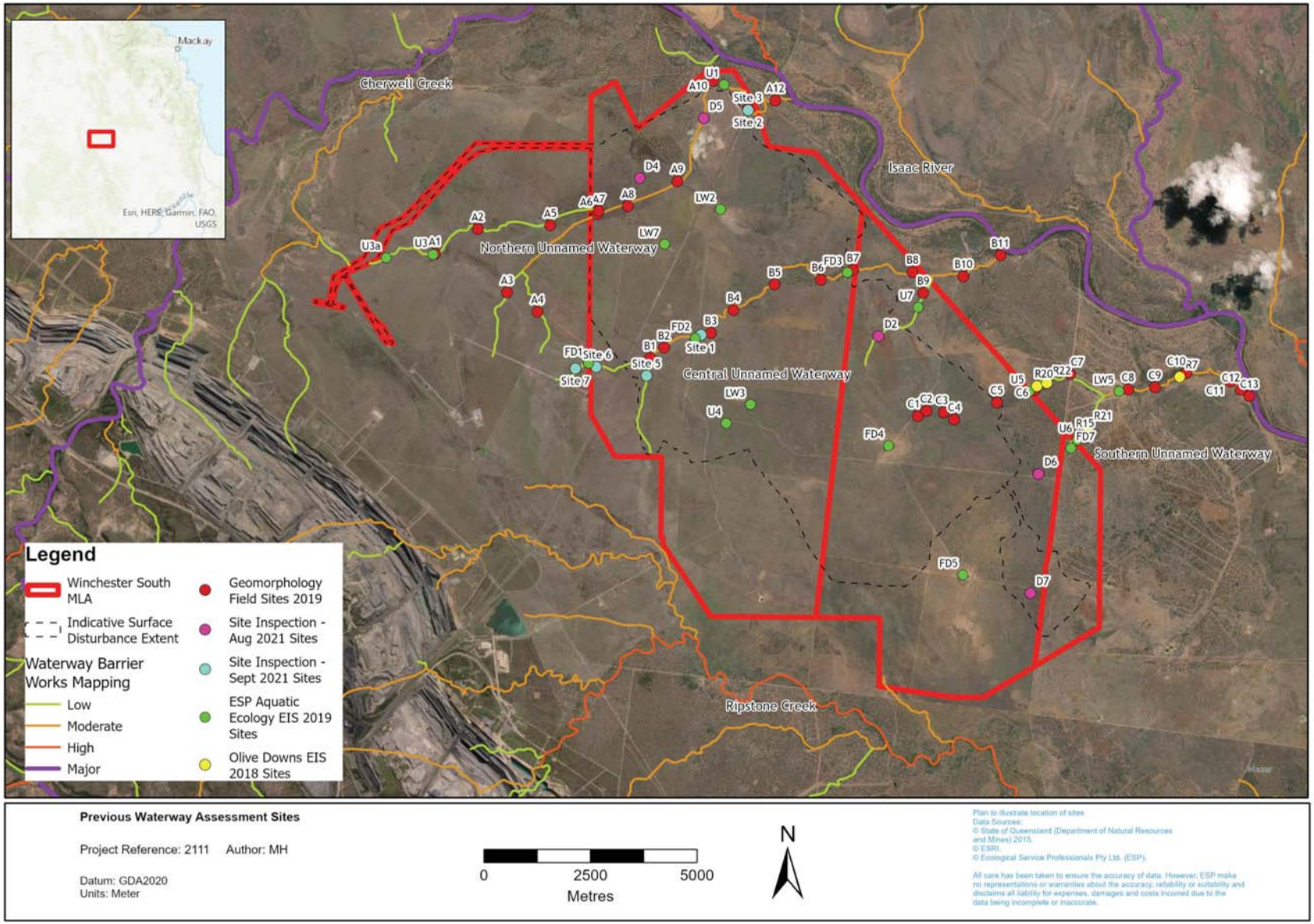


Figure 3.4 Previous waterway assessment sites

3.1.2.2 Northern Unnamed Waterway

Most of the northern unnamed waterway is a drainage feature under the Water Act (Figure 3.1). The desktop assessment of previous surveys and photographs confirmed that it is a drainage feature, from the highest upstream assessment sites on mapped green tributaries (i.e. Sites U3a, A3 and A4), downstream to A10 (Figure 3.4). The drainage feature between these sites conveys overland flows during periods of localised rainfall that do not continue beyond the duration of a rain event. Due to the lack of waterway features, including: a lack of standing water/evidence of past standing water, no riparian vegetation or other features of fish habitat, and no defined, continuous channel with bed and banks, this reach of the mapped feature is not considered a waterway within the definition provided by DAF (2022), nor a waterway providing for fish passage MSES as defined under the EO Regulation.

The section of mapped amber waterway between Sites A10 and A12 (Figure 3.4) may have the characteristics of a waterway as defined by DAF (2022) and provide fish passage opportunities during periods of flow from upstream catchments. There appears to be a defined bed and banks downstream from Site A10. The width and gentle grade observed in images of the mapped waterway suggest flow may be slow enough to allow for an extended period of flow following periods of rainfall. Habitat features are present at all sites downstream from Site A10 (including large woody debris, and depressions that would form pools during periods of flow). Therefore, based on the desktop assessment, the mapped feature from Site A10 through to Site A12 exhibits qualities of a waterway as defined by DAF (2022) and a watercourse under the Water Act, i.e. it is a waterway providing for fish passage MSES as defined under the EO Regulation.

This assessment was refined during the field survey, extending the area of the mapped feature exhibiting the qualities of a waterway upstream to just south of the large quarry (i.e. 4.5 km upstream of the confluence with the Isaac River, as discussed in Section 3.1.3.1), aligning closely with existing DRDMW WIM mapping where the feature is mapped as a watercourse (Section 3.1.1).

3.1.2.3 Central Unnamed Waterway

A large section of the central unnamed waterway is not included on the DRDMW WIM mapping (i.e. it is not considered a drainage feature or watercourse under the Water Act). The desktop assessment of previous surveys and photographs indicated the central unnamed waterway from Sites 7 and B1 downstream to Site B8, and from Site D2 through to Site B9, is characterised as a drainage depression, gully or overland flow area (Figure 3.4). The drainage feature / overland flow path between these sites likely conveys overland flows and does not provide adequate flow beyond an immediate rainfall event.

Due to the lack of waterway features including a lack of standing water/evidence of past standing water, no riparian vegetation or other features of fish habitat, and no defined, continuous channel with bed and banks, this reach of the mapped feature is not considered a waterway as defined by DAF (2022) or a waterway providing for fish passage MSES as defined under the EO Regulation.

Downstream of Sites B8 and B9 through to at least B11 exhibits qualities of a waterway as defined by DAF (2022), and may be considered a waterway providing for fish passage. The section of the mapped feature exhibiting the characteristics of a waterway is similar to, but downstream of, existing DRDMW WIM mapping where the feature is mapped as a watercourse (Section 3.1.1).

This assessment was refined during the field survey (Section 3.1.3.2).

3.1.2.4 Southern Unnamed Waterway

The southern unnamed waterway lacks the features of a waterway providing for fish passage. Assessments from Site FD4, upstream of the current WWBW mapping, downstream to Site C13 indicate this waterway is a drainage feature that conveys overland flows during periods of localised rainfall, consistent with the DRDMW WIM mapping. The assessed sites along this waterway consistently indicated that there is no evidence of a defined, continuous channel with bed and banks, periods of flow extending beyond localised rainfall events, adequate flow to sustain ecological processes or any connectivity to upstream habitats.

3.1.3 Supplementary Waterway Surveys

3.1.3.1 Northern Unnamed Waterway

The supplementary field surveys found the mapped feature from Site 97 through to Site 98 (and therefore, downstream to the Isaac River) has defined bed and banks, is a watercourse under the Water Act and provides for the natural movement of freshwater fish species required to maintain the biological integrity of the species. It is therefore a waterway providing for fish passage MSES as defined under the EO Regulation (Figure 2.2).

Upstream of Site 97, the mapped feature lacks the features required to be considered a waterway as defined by DAF (2022), consistent with the findings of the desktop assessment. In parts of the mapped amber feature (Figure 2.2), no discernible drainage feature could be found, indicating a substantial break in connectivity that would prevent fish passage further upstream. Significant barriers, including quarry walls, dam walls, and road crossings, also act as significant barriers to fish passage.

Upstream of Site 97, the drainage feature likely conveys overland flows during periods of localised rainfall. Due to the lack of waterway features including a lack of standing water/evidence of past standing water, no riparian or aquatic vegetation, and no defined, continuous channel with bed and banks, the mapped reaches upstream of Site 97 are not considered a waterway as defined by DAF (2022), nor a waterway providing for fish passage MSES as defined under the EO Regulation.

The northern unnamed waterway contained 4.5 km of waterway providing for fish passage. Of this, 1.52 km (constituting 2.45 ha) is within the proposed surface disturbance extent of the Project.

Figure 3.5 and Figure 3.8 provides the new proposed WWBW mapping for the northern unnamed waterway.

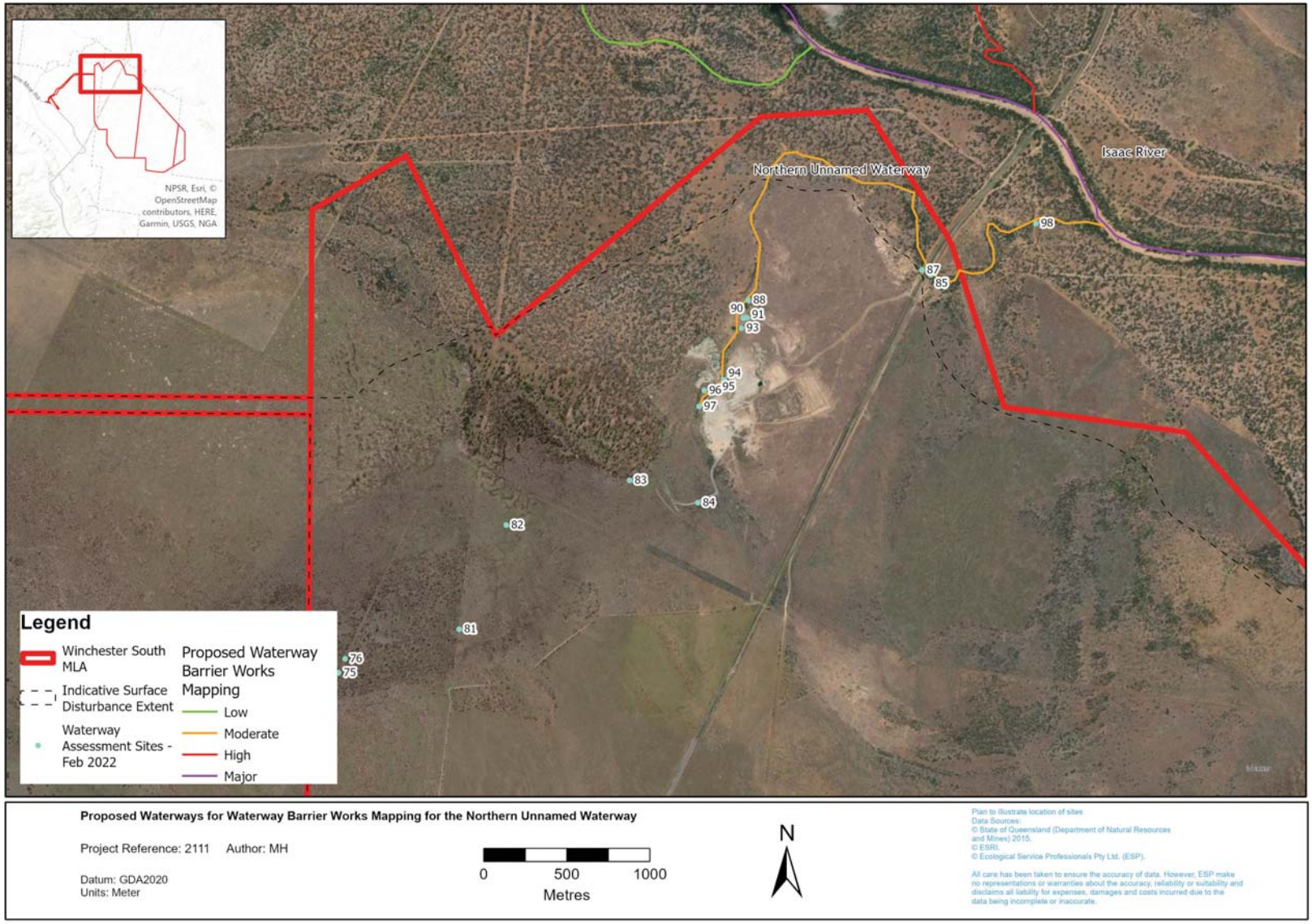


Figure 3.5 Proposed mapping change to the WWBW mapping for the northern unnamed waterway

3.1.3.2 Central Unnamed Waterway

The supplementary field surveys found that the central unnamed waterway exhibits the qualities of a waterway, as defined by DAF (2022), commencing at Site 62 (which is downstream of the proposed surface disturbance extent) and continuing downstream to Site 58 on the amber mapped waterway (Figure 2.2). While no standing water was found in the channel, several depressions were identified that likely provided standing water during and after periods of flow. This section of the waterway is a watercourse under the Water Act, and contained multiple fish habitat opportunities (including woody debris and rocky structures, as well as defined bed and banks), and provides for the natural movement of freshwater fish species required to maintain the biological integrity of the species. It is therefore a waterway providing for fish passage commencing at Site 62 continuing downstream. It is assumed that there are waterway features downstream of Site 58 to the Isaac River.

Upstream of Site 62, and upstream of Site 56 on the mapped green tributary (Figure 2.2), large sections of the mapped feature consist of broken sections of a drainage depression with no continuously defined bed or banks. Our field surveys found the mapped feature is best described as a drainage depression, or gully, that conveys overland flows and does not flow beyond an immediate rainfall event. As such, there is not adequate flow to maintain aquatic ecological processes and it does not meet the definition of a waterway under the EO Regulation as it is a drainage feature. While there are some depressions that hold water, there is a lack of connectivity for fish to access and use these depressions.

The central unnamed waterway contained 3.54 km of waterway providing for fish passage, with 1.37 km (constituting 2.12 ha) within the boundary of the Winchester South MLA; however, the waterway does not extend into the proposed surface disturbance extent. As such, for the purposes of this Project, it is not a waterway providing for fish passage MSES as defined under the EO Regulation.

Figure 3.6 and Figure 3.8 provides the new proposed WWBW mapping for the mapped feature.

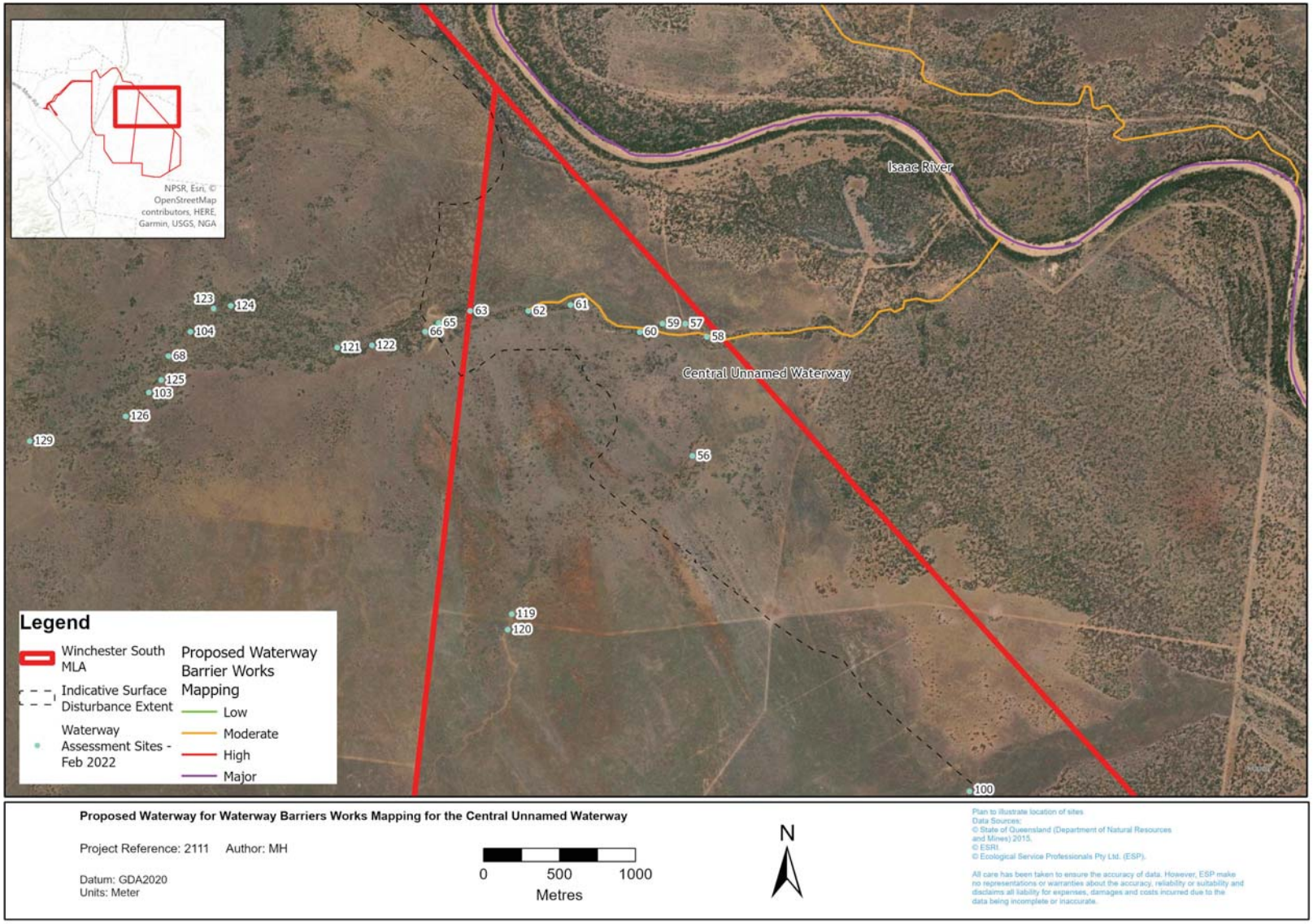


Figure 3.6 Proposed mapping change to the WWBW mapping for the central unnamed waterway

3.1.3.3 Southern Unnamed Waterway

The supplementary field surveys from Site 111, upstream of the current WWBW mapping, downstream to Site 151 indicated the southern unnamed waterway is a drainage feature that conveys overland flows during periods of localised rainfall. This is consistent with the DRDMW WIM mapping. The unnamed waterway consists of broken sections of a drainage channel and man-made dams.

The assessed sites along this section of the feature consistently indicated that there is no evidence of a defined, continuous channel with bed and banks, periods of flow extending beyond localised rainfall events, adequate flow to sustain aquatic ecological processes, or any connectivity to upstream habitats.

The southern unnamed waterway, upstream from Site 151, lacks the features of a waterway providing for fish passage. Downstream of Site 151 (which is downstream of the proposed surface disturbance extent), the waterway exhibits the qualities of a waterway, as defined by DAF (2022). However, as this is a drainage feature under the Water Act, it is not a waterway providing for fish passage MSES as defined under the EO Regulation.

Figure 3.7 and Figure 3.8 provides the new proposed WWBW mapping for the mapped feature.

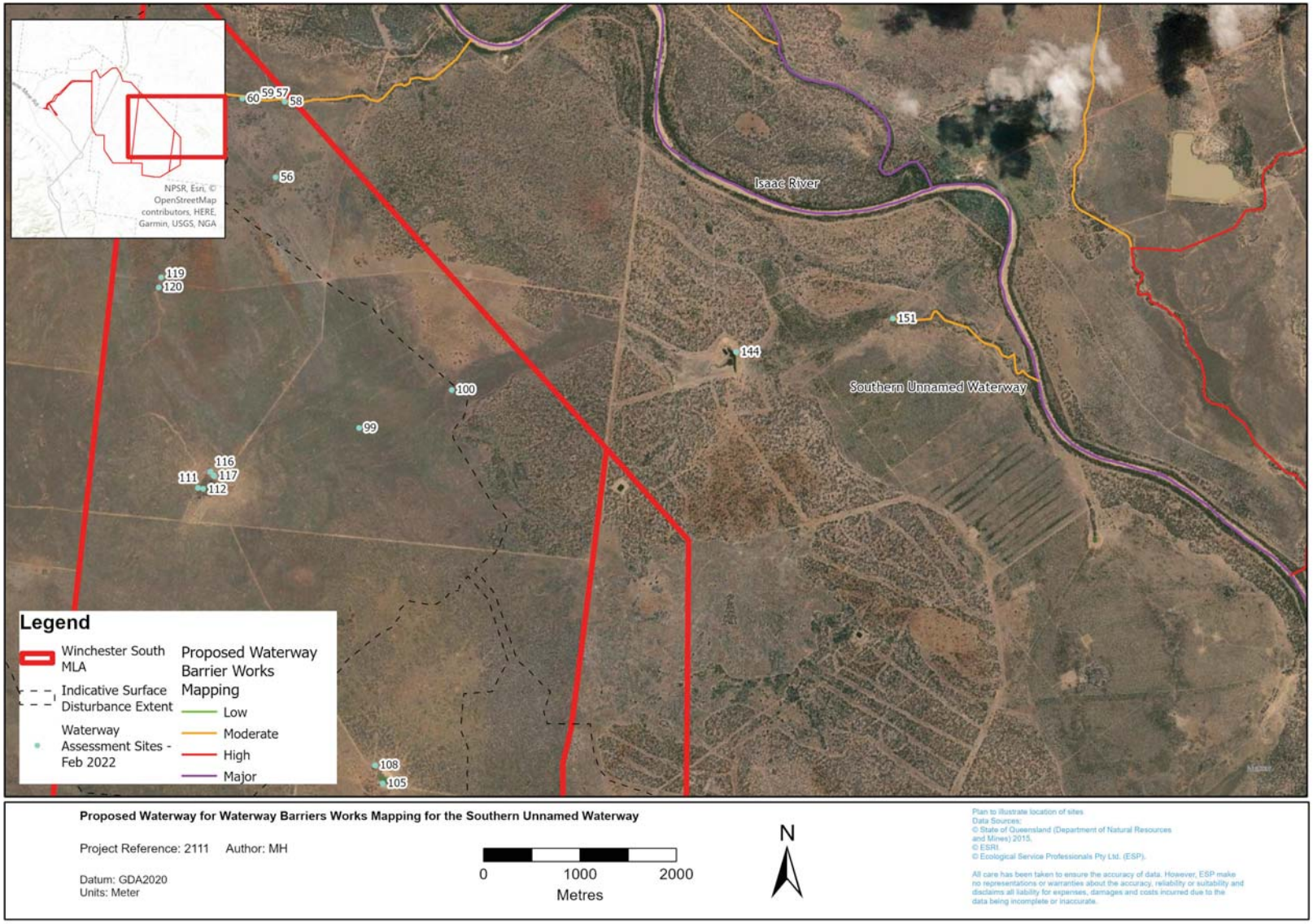


Figure 3.7 Proposed mapping change to the WWBW mapping for the southern unnamed waterway

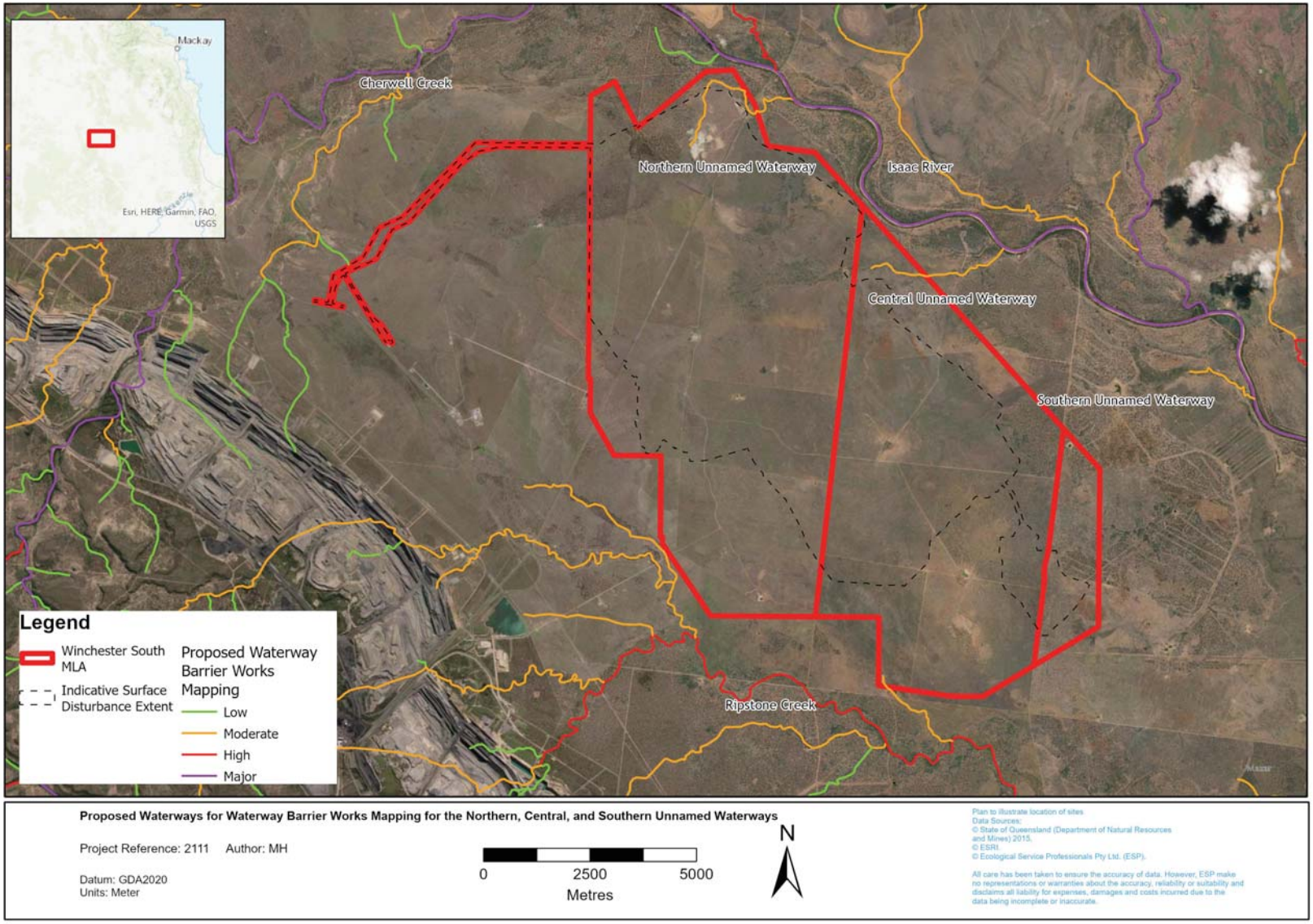


Figure 3.8 Proposed mapping change to the WWBW mapping for unnamed waterways across the Project area

3.2 Fish Communities

3.2.1 Review of Existing Information

3.2.1.1 Survey Timing and Rainfall Conditions

Information for survey timing and rainfall information for the aquatic ecology baseline surveys in 2011 and 2012 (frc environmental 2012), Olive Downs EIS in 2016 and 2017 (DPM Enviroscienses 2018), and aquatic ecology EIS surveys in 2019 (ESP 2021) are detailed in Section 3.1.2.1.

3.2.1.2 Summary of Fish Survey Results from Desktop Review

Within the study area, a total of 15 species were recorded across all surveys, with seven species (including one exotic species, Mozambique tilapia, *Oreochromus mossambicus*) recorded from sites on waterways, and 15 species (including one exotic species, Mozambique tilapia) recorded from sites on farm dams (Table 3.1). Fish communities were dominated by small-bodied species, with the lack of large-bodied fish likely due to the paucity of deep pool habitats within the study area.

Fish were recorded at most sites surveyed for fish, except Site U4. Native species richness was highest at Site P5 (10 native species), followed by Sites L2 and R13 (nine native species). Site U1, when surveyed by ESP in 2019, only contained one native species (compared with four native species when surveyed during the baseline surveys in 2012).

The lack, or low diversity, of native species across some survey sites may be indicative of the ephemeral nature of the waterways across the study area, where complete wetting and drying within tributaries may limit the persistence of native fish.

Agassiz's glassfish (*Ambassis agassizii*) was the most widespread species, recorded in nine of the eleven instances. Eastern rainbowfish (*Melanotaenia splendida splendida*) (eight sites) and carp gudgeons (*Hypseleotris* spp.) (seven sites) were also widespread across survey locations. The exotic Mozambique tilapia, listed as a restricted noxious pest under the *Biosecurity Act 2014,* was found in six of the eleven instances, including two sites on constructed farm dams.

All native fish species identified during the fish surveys require some physical instream habitat for shelter and/or reproduction. A variety of physical aquatic habitat (e.g. woody debris and substrate diversity) also supports diverse macroinvertebrate communities, which are prey to many of the fish in the survey area. Most of the surveyed species can tolerate a broad range of water quality conditions.

Along the Isaac River, there were no obvious spatial patterns in the distribution of small-bodied species. The greatest species richness was recorded at Sites R6, R23, and I3 (ESP 2021) (10 native species) (Table 3.2). The lowest species richness was found at Sites I1A (ESP 2021) and I3 (frc environmental 2012) (five native species at each site). Mozambique tilapia were recorded at six sites.

The fish survey results confirm our waterway assessment and recommended mapping changes as described in Section 3.1.3 above. Fish were captured in a number of the farm dams surveyed, but there was no evidence of connectivity to waterways upstream or downstream of these dams. Fish were found within the waterway channel sites surveyed on the unnamed mapped waterways (U1 and U2); these sites are within the field-verified waterways providing for fish passage, based on detailed habitat assessments.

Table 3.1 Fish taxa previously recorded within the project area and connecting tributaries

Species Name	Common Name	Recorded Locations										
		DPM 2016 ¶ 2017			ESP 2019						FRC 2011 & 2012	
		R13[1]	P5[1]	L2[1]	U1	U4	FD2[1]	FD4[1]	FD6[1]	RTC4	U1	U2
Fish												
Ambassis agassizii	Agassiz's glassfish	✓	✓	✓	✓	–	✓	✓	✓	–	✓	✓
Amniataba percoides	barred grunter	–	✓	–	–	–	–	–	–	–	–	–
Anguilla reinhardtii	marbled eel	✓	–	–	–	–	–	–	–	–	–	–
Craterocephalus stercusmuscarum	fly-specked hardyhead	✓	✓	✓	–	–	✓	✓	✓	–	–	–
Hypseleotris spp.	carp gudgeon	✓	✓	✓	–	–	✓	✓	✓	–	✓	–
Leiopotherapon unicolor	spangled perch	✓	✓	✓	–	–	✓	–	–	✓	–	–
Melanotaenia splendida splendida	eastern rainbowfish	✓	✓	✓	–	–	✓	✓	✓	–	✓	✓
Mogurnda adspersa	purple-spotted gudgeon	✓	–	✓	–	–	–	–	✓	–	✓	–
Nematalosa erebi	bony bream	–	–	✓	–	–	✓	✓	✓	–	–	–
Neosilurus hyrtlii	Hyrtl's tandan	✓	✓	–	–	–	✓	–	–	–	–	✓
*Oreochromus mossambicus**	Mozambique tilapia	✓	✓	✓	✓	–	✓	✓	–	–	–	–
Oxyeleotris lineolata	sleepy cod	✓	✓	–	–	–	✓	–	–	–	–	–
Porochilus rendahli	Rendahl's tandan	–	✓	–	–	–	–	✓	–	–	–	–

Species Name	Common Name	Recorded Locations										
		DPM 2016 ¶ 2017			ESP 2019						FRC 2011 & 2012	
		R13[1]	P5[1]	L2[1]	U1	U4	FD2[1]	FD4[1]	FD6[1]	RTC4	U1	U2
Retropinna semoni	Australian smelt	–	–	✓	–	–	–	–	–	–	–	–
Tandanus tandanus	freshwater catfish	–	✓	✓	–	–	–	–	–	–	–	–
Native Species Richness		**9**	**10**	**9**	**1**	**0**	**8**	**6**	**6**	**1**	**4**	**3**
Exotic Species Richness		**1**	**1**	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**0**

* restricted noxious pest species under the *Biosecurity Act 2014*

– not recorded

[1] constructed farm dam

Table 3.2 Fish taxa previously recorded within the Isaac River, adjacent to and downstream of the Project area

Species Name	Common Name	Recorded Locations									
		DPM 2016 & 2017			ESP 2019				FRC 2011 & 2012		
		R6	R8	R23	I1	I1a	I2a	I3	I1	I2	I3
Ambassis agassizii	Agassiz's glassfish	✓	–	✓	✓	✓	✓	✓	✓	✓	✓
Amniataba percoides	barred grunter	✓	✓	–	–	–	–	–	–	–	–
Anguilla reinhardtii	marbled eel	✓	–	–	–	–	–	–	–	–	–
Craterocephalus stercusmuscarum	fly-specked hardyhead	–	✓	–	–	–	–	–	–	–	–
Hypseleotris spp.	carp gudgeon	✓	✓	✓	✓	✓	✓	✓	–	✓	✓
Leiopotherapon unicolor	spangled perch	✓	✓	✓	✓	–	✓	✓	✓	✓	✓
Macquaria ambigua	golden perch	–	✓	–	✓	–	✓	✓	✓	–	–
Melanotaenia splendida splendida	eastern rainbowfish	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mogurnda adspersa	purple-spotted gudgeon	✓	✓	✓	–	–	✓	✓	–	✓	✓
Nematalosa erebi	bony bream	✓	✓	✓	–	✓	–	✓	✓	–	–
Neosilurus hyrtlii	Hyrtl's tandan	✓	✓	–	✓	–	✓	✓	–	–	–
*Oreochromus mossambicus**	Mozambique tilapia	✓	✓	✓	✓	–	✓	✓	–	–	–
Oxyeleotris lineolata	sleepy cod	✓	✓	✓	–	–	–	✓	✓	✓	–
Porochilus rendahli	Rendahl's tandan	–	–	–	–	–	–	–	–	–	–
Retropinna semoni	Australian smelt	–	–	–	–	–	–	✓	–	–	–

Species Name	Common Name	Recorded Locations									
		DPM 2016 & 2017			ESP 2019				FRC 2011 & 2012		
		R6	R8	R23	I1	I1a	I2a	I3	I1	I2	I3
Tandanus tandanus	freshwater catfish	–	–	✓	–	✓	–	–	–	–	–
Scortum hillii	leathery grunter	–	–	–	–	–	–	–	✓	–	–
Native Species Richness		**10**	**10**	**8**	**6**	**5**	**7**	**10**	**7**	**6**	**5**
Exotic Species Richness		**1**	**1**	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**0**

* restricted noxious pest species under the *Biosecurity Act 2014*

– not recorded

3.2.2 Supplementary Fish Surveys

During the supplementary fish survey in February 2022, 312 native fish comprising four species were captured; 46 native fish comprising three native species were captured from isolated pools on waterways, and 266 native fish comprising four native species were captured from a constructed dam (Table 3.3). Crimson-spotted rainbowfish (*Melanotaenia duboulayi*) and spangled perch (*Leiopotherapon unicolor*) were the most abundant fish species (177 and 95 individuals, respectively). Twenty-nine Agassiz's glassfish (*Ambassis agassizii*) and 11 gudgeons from the carp gudgeon species complex (*Hypseleotris* spp.)[1] were also captured.

Only two exotic Mozambique mouthbrooder/tilapia (*Oreochromis mossambicus*) were captured at a single site during the fish survey (Table 3.3), despite their prevalence in the Isaac River and local tributaries more generally (ESP, pers. obs.).

Fish abundance was variable across the survey sites. Site Q1 (large dam within onsite quarry area) had the highest abundance, with 266 individuals (species richness – four species). Site QN1 had the second highest abundance, with 41 individuals (species richness – three species). Further upstream, seven fish were caught at Site QS1, including two exotic tilapia (species richness – three species).

The length ranges of native fish captured showed some variety of life history stages (i.e. juveniles, intermediate and adult sized fish were caught) between sites. Adult and intermediate life stages were more common at all sites. The number of juveniles was low, with only five individuals captured across all sites; with no juvenile fish captured at Site QS1 and a single juvenile fish captured at Site QN1.

The low abundance of fish at Site QS1, upstream of the large dam, is likely due to barriers to fish passage upstream of the dam, including a steep incline which may reduce the period of flow between these two water bodies.

Site QN1 was an isolated green coloured pond which appeared to be quickly drying and lacked connectivity to upstream reaches. A diversion has been created downstream of Site QN1, connecting the large dam (Site Q1) with the northern unmapped waterway. The upstream reaches of Site QN1 appear to have been completely blocked by large quarry stone and fill. Any flows entering Site QN1 are likely from overland flows and would only provide short periods of connectivity to downstream reaches. Fish following flows upstream into Site QN1 are likely to become trapped in this small pool, with no further connectivity upstream; that is, Site QN1 is acting as an ecological trap, or sink, where species become 'trapped' by following environmental cues into habitat that does not provide the habitat qualities required to persist.

[1] *Hypseleotris* spp. includes firetail gudgeons *(Hypseleotris galii*) and common carp gudgeons (*Hypseleotris* sp.); these species are difficult to reliably identify to species level in the field, and can hybridise.

Table 3.3 Fish species recorded during February 2022 fish survey

Family	Species Name	Common Name	QS1		Q1 [1]		QN1		Total Count
			Count	Size range (mm)	Count	Size range (mm)	Count	Size range (mm)	
Ambassidae	*Ambassis agassizii*	Agassiz's glassfish	0	–	24	31-75	5	13-55	**29**
Eleotridae	*Hypseleotris* spp.	carp gudgeon	0	–	11	13-30	0	–	**11**
Melanotaeniidae	*Melanotaenia duboulayi*	crimson-spotted rainbowfish	3	56-60	147	29-87	27	30-55	**177**
Cichlidae	*Oreochromis mossambicus*	Mozambique tilapia	2	78-79	0	–	0	–	**2**
Terapontidae	*Leiopotherapon unicolor*	spangled perch	2	44-45	84	61-176	9	35-75	**95**
Exotic abundance			**2**		**0**		**0**		**2**
Native abundance			**5**		**266**		**41**		**312**
Exotic richness			**1**		**0**		**0**		**1**
Native richness			**2**		**4**		**2**		**4**

* restricted noxious pest species under the *Biosecurity Act 2014*

[1] constructed dam

4 Stygofauna

4.1 Review of Existing Information

Stygofauna surveys were completed for the Draft EIS in May and October 2019, and January 2020. Sampling was completed at eleven bores, including bores within the Isaac River alluvium (Table 2.2). Each bore was established at least six months prior to stygofauna sampling and contained groundwater. In-situ water quality measurements for electrical conductivity and pH were also taken at each bore, to aid in the interpretation of results. A detailed discussion of methodologies and results for stygofauna sampling are provided in the Aquatic Ecology and Stygofauna Assessment completed for the Draft EIS (ESP 2021), with a summary presented below.

No stygofauna specimens were recorded from bores sampled during the field survey for the Draft EIS (ESP 2021). Electrical conductivity and pH of groundwater were within the range known to support stygofauna at all bores. The regolith is considered to be largely unsaturated throughout the region, with the presence of highly saline water occurring in the lower elevation areas along the Isaac River and the lower reaches of its tributaries (such as Ripstone Creek) (DPM Enviros ciences 2018). The high EC of the regolith throughout the broader region suggests that the groundwater environment is not ideal for stygofauna; however, stygofauna are likely to occur in the alluvium associated with the Isaac River (DPM Enviros ciences 2018).

Two bores in the Isaac River alluvium were sampled as part of a stygofauna pilot study completed for the Olive Downs Project EIS (DPM Enviros ciences 2018). Although stygofauna were considered likely to occur in these unconsolidated sediments, none were recorded during the study.

A recent stygofauna pilot study prepared for the Isaac Downs Project (located approximately 13 km north of the Project) (frc environmental 2019), that included surveys of bores adjacent to the Isaac River, found two stygofauna specimens of the Orders Copepoda (copepod) and Nematoda (worm) in a single bore. A recent stygofauna pilot study prepared for the Vulcan Complex Project (located approximately 10 km south-west of the Project) (frc environmental 2020) found one stygofauna specimen of the Order Ostracoda (seed shrimp) in each of two bores. However, copepods, ostracods and nematodes are stygoxenic fauna, meaning they are aquatic fauna that will use groundwater ecosystems, but they are not dependent on groundwater to complete their lifecycle; that is, they are not obligate inhabitants of groundwater ecosystems and are unable to establish populations in such environments (frc environmental 2019, 2020).

The closest known record of obligate stygofauna taxa (i.e. stygobitic) to the Project was recorded during a pilot study in 2019 for the Moorvale South Coal Project, approximately 5 km north-east of the Project. During the study, 11 syncarid shrimp were recorded from a bore in the Isaac River alluvium (pers. comms. Peabody Pty Ltd 2022). This result was expected given that stygofauna are likely to occur in the unconsolidated alluvial aquifers associated with the Isaac River. Stygoxenic taxa (including mites, copepods, and segmented worms) were also recorded during this pilot study (pers. comms. Peabody Pty Ltd 2022).

4.2 Supplementary Stygofauna Surveys

4.2.1 In-situ Water Quality

Electrical conductivity and pH of groundwater was within the range known to support stygofauna at all bores in February 2022.

In-situ measurements recorded during field sampling showed that groundwater was close to neutral at most bores (with pH typically ranging from 6.4 to 7.7) (Table 4.1). The exception was bore IF3860P, which was slightly acidic (pH of 5.3). Though still within the range known to support stygofauna (pH range of 3.5 to 10.3), a higher diversity is likely to occur in aquifers with a pH range of 6.5 to 7.5 (4T 2012).

Electrical conductivity varied substantially among bores, ranging from 340.6 micro Siemens per centimetre (µS/cm) to 18,200.0 µS/cm. Although stygofauna have been collected from aquifers with electrical conductivity of up to 56,000 µS/cm, the diversity and abundance of stygofauna typically decreases with increasing electrical conductivity above 5,000 µS/cm (Hancock & Boulton 2008, Watts & Humphreys 2009, Schulz et al 2013, Glanville et al 2016).

Table 4.1 In-situ water quality recorded at each bore in February 2022

Bore	Aquifer	pH (pH Units)	Electrical Conductivity (µS/cm)
Wynette Bore	Alluvium	7.7	7,034.8
Knob Hill 2	Alluvium	7.0	488.7
MB3	Regolith	6.4	18,200.0
IF3860P	Alluvium	5.3	4,258.1
IF3862P	Alluvium	6.6	8,573.0
IF3839P	Alluvium	6.4	340.6

4.2.2 Stygofauna

Two stygofauna taxa were recorded from one bore targeting the Isaac River alluvium (i.e. bore IF3839P):

- Ostracods from family Candonidae (2 specimens), and
- Syncarida from family Bathynellidae (10 specimens).

Both of these families are obligate inhabitants of groundwater ecosystems (i.e. stygobites).

Bathynellidae are widespread and occur in most alluvial aquifers across Australia. The taxonomy of the family Bathynellidae is relatively unresolved, with only a few genera described (Peter Hancock 2022, pers. comm.). All are obligate groundwater dwellers that rely on groundwater habitats for their entire lifecycle.

Candonidae includes both surface water and groundwater dwelling ostracod species. Although it was not possible to identify the specimens recorded during the current survey to species level, examination of key features determined that they were likely obligate stygofauna species (Peter Hancock 2022, pers. comm.).

Findings from the supplementary stygofauna surveys in February 2022 were consistent with conclusions from the EIS, which concluded that stygofauna were likely to occur in areas of the alluvium along the Isaac River, and lower reaches of its larger tributaries.

5 Conclusion

The assessed waterways, drainage features and farm dams within and adjacent to Project area were typical of ephemeral systems in the broader region. Waterways were dry at the time of sampling with no standing water except for within constructed dams, and downstream reaches of waterways close to the Isaac River.

A review of previous aquatic habitat assessments supplemented with an additional onsite waterway assessment found large sections of the three unnamed waterways mapped on the WWBW spatial layer lacked the features required to be considered a waterway, as defined by DAF (2022) or a waterway providing for fish passage MSES as defined under the EO Regulation.

Waterway assessments consistently indicated that the mapped features:

- Lacked continuously defined bed and banks upstream and downstream of the assessment site:
    - many sections of assessed waterway contained broken sections of a drainage depression, and
    - eroded banks visible in aerial images are indicative of high flows at times, but there was no evidence of flows persisting after rainfall events, sufficient to maintain basic aquatic ecological processes.
- Had no aquatic vegetation, other than in discrete patches within water-holding dams, or sections of the mapped features that did meet the definition of a waterway providing for fish passage.
- Contained significant fish passage barriers:
    - raised dam walls (for dams that have been in place for many years) with steep slopes
    - quarry walls and rock barriers, and
    - road crossings with raised narrow culverts.
- Lacked fish habitat, other than within the water-holding dams and ground-truthed waterways:
    - many sections are gullies with no instream habitat features (submerged logs, overhanging vegetation, etc.).
- Appeared to have insufficient flow or water availability to sustain basic ecological processes and habitats:
    - all instream survey sites were dry at the time of surveys, except for the lower sections of the northern unnamed waterway within the areas defined as a waterway providing for fish passage
    - flows at most sites are unlikely to continue beyond the duration of a rain event, and

- the surveyed channels likely funnel immediate localised rainfall rather than flow that has arisen from an upstream catchment.

Sections of waterway exhibiting the qualities of a waterway as defined by DAF (2022) and a waterway providing for fish passage under the EO Regulation were identified on the northern and central unnamed waterways (a total area of 2.45 ha within the proposed surface disturbance extent). The northern unnamed waterway contained 4.5 km of waterway providing for fish passage, with 1.52 km (constituting 2.45 ha) within the proposed surface disturbance extent of the Project. The central unnamed waterway contained 3.54 km of waterway providing for fish passage, of which all is outside of the proposed surface disturbance extent. Regarding a 'waterway providing for fish passage', the EO Regulation states that any part of a waterway providing for passage of fish is a MSES only if the construction, installation or modification of waterway barrier works carried out under an authority will limit the passage of fish along the waterway. Therefore, only the northern unnamed waterway is a MSES relevant to the Project.

Fish communities recorded at sites were typical of those inhabiting ephemeral systems in central Queensland. All taxa recorded were common in the broader region, and no listed threatened species known from the catchment (or potential habitat for these species) were identified. While farm dams support fish communities, downstream connectivity was limited by high dam walls. The farm dams are barriers to fish passage, particularly as there were rarely waterway channels present upstream or downstream of the dams. The fish survey results confirmed the waterway assessment and recommended amendments to the waterway mapping.

Two stygofauna taxa were recorded from a single bore targeting the Isaac River alluvium. This is consistent with conclusions from the EIS (ESP 2021), which concluded that stygofauna were likely to occur in areas of the alluvium along the Isaac River and lower reaches of its larger tributaries. The groundwater assessment undertaken for the Draft EIS and supplementary analysis completed by SLR (2022) concluded that the Project is unlikely to impact the Isaac River alluvium.

6 References

4T 2012, *Desktop assessment of likelihood of stygofauna occurrence in the Bowen Basin*, Report to URS Australia Pty Ltd.

Bureau of Meteorology 2022, *Monthly rainfall, Moranbah Airport*. Available at http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_stn_num=034035.

Department of Agriculture and Fisheries 2018, *Accepted development requirements for operational work that is constructing or raising waterway barrier works.*

Department of Agriculture and Fisheries 2020, *Queensland waterways for waterway barrier works*. Updated data available at http://qldspatial.information.qld.gov.au/catalogue//.

Department of Agriculture and Fisheries 2021, *Winchester South Waterways technical agency assessment response*, report prepared by DAF for Whitehaven Coal.

Department of Agriculture and Fisheries 2022, *What is a waterway?* Available at https://www.daf.qld.gov.au/business-priorities/fisheries/habitats/policies-guidelines/factsheets/what-is-a-waterway

Department of Environment and Science 2015, *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna*, Queensland Government Department of Environment and Science, licensed under Creative Commons Attribution 4.0 sourced on 19 October 2019.

Department of Environment and Science 2019, *Wetland data - version 5 - wetland lines – Queensland*. Updated data available at http://qldspatial.information.qld.gov.au/catalogue//.

DPM Enviros ciences 2018, *Olive Downs Coking Coal Project – Aquatic Ecology Assessment,* report prepared for Pembroke Resources Pty Ltd.

Department of Regional Development, Manufacturing and Water 2022, *The Watercourse Identification Map (WIM) [Water Act 2000 section 5AA] series: watercourses, drainage features, downstream limits, lakes, springs*. Updated data available at http://qldspatial.information.qld.gov.au/catalogue//.

ESP 2021, *Winchester South Project: Aquatic Ecology and Stygofauna Assessment,* report prepared by ESP for Whitehaven WS Pty Ltd.

Fluvial Systems 2020, Winchester South Project: Geomorphology Field Survey Sites, report prepared by Fluvial Systems for Whitehaven WS Pty Ltd.

frc environmental 2012, *Winchester South Project: Aquatic Ecology Baseline Study,* report prepared by frc environmental for Rio Tinto Coal Australia.

frc environmental 2019, *Isaac Downs Coal Project: Stygofauna Pilot Study*, report prepared by frc environmental for Stanmore IP South Pty Ltd.

frc environmental 2020, *Vulcan Complex Project Stygofauna Pilot Study*, report prepared by frc environmental for Vitrinite Pty Ltd.

Glanville K, Schulz C, Tomlinson M & Butler D 2016, 'Biodiversity and biogeography of groundwater invertebrates in Queensland', Australia, *Subterranean Biology*, 17, 55.

Hancock PJ & Boulton AJ 2008, 'Stygofauna biodiversity and endemism in four alluvial aquifers in eastern Australia', *Invertebrate Systematics* 22, 117-126.

QTopo 2020, *Topographic information mapping spatial layer,* https://qtopo.information.qld.gov.au/, accessed January 2022.

Schulz C, Steward AL & Prior A 2013, Stygofauna presence within fresh and highly saline aquifers of the Border Rivers region in southern Queensland, *Proceedings of the Royal Society of Queensland,* 118: 27–35.

SLR Consulting Australia Pty Ltd 2022, *Winchester South Project Supplementary Groundwater Assessment,* report prepared for Whitehaven WS Pty Ltd.

Watts CHS & Humphreys WF 2009, Fourteen new Dytiscidae (Coleoptera) of the genera *Limbodessus* Guignot, *Paroster* Sharp and *Exocelina* Broun, from underground waters in Australia, *Transactions of the Royal Society of South Australia,* 133: 62–107.

Whitehaven Coal 2021, *Winchester South Project: Waterway Site Inspections*, report prepared by Whitehaven Coal for DAF.

Appendix A Desktop Review Individual Site Assessment Results

Northern Unnamed Waterway

Site U3a

Site U3a is a drainage depression (Figure 6.1). There are no defined bed or banks, or any other waterway features. There is no visible standing water. The depression appears to be a drainage feature that funnels immediate localised rainfall and would not likely provide flow beyond the duration of a rain event.

The lack of defined bed and banks, in combination with insufficient water availability to sustain basic ecological processes and habitats, and the lack of riparian vegetation, suggest this reach of the mapped feature is not a waterway providing for fish passage.

Figure 6.1 Site U3a (Photos from EIS; ESP 2021)

Site A1 (U3) and A2

Sites A1 (U3) and A2 appear as drainage features, with no visible standing water (Figure 6.2 and Figure 6.3). The drainage feature appears to form a channel that funnels immediate localised rainfall, but that would not likely provide flow beyond the duration of a rain event. Vegetation appears to be terrestrial grasses, with no aquatic plants. Site A1 upstream appears to consist of broken sections of a depression. This section of the waterway is not a waterway providing for fish passage.

Figure 6.2 Sites A1 (U3) and A2 (from Geomorphology Assessment; Fluvial Systems 2020)

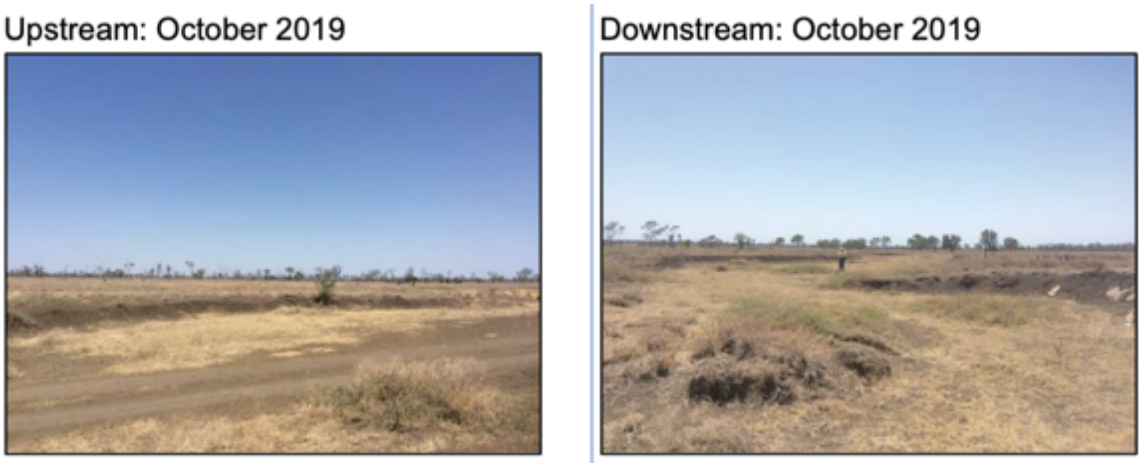


Figure 6.3 Site U3 (A1) (Photos from EIS; ESP 2021)

Site A3

Site A3 appears to be an eroded drainage feature (Figure 6.4). There is no evidence of previous standing water and no aquatic plants visible. The feature appears to funnel immediate localised rainfall and would not likely provide adequate flow beyond the duration of a rain event. This section of the waterway does not appear to provide fish habitat or for fish passage.

Figure 6.4 Site A3 (from Geomorphology Assessment; Fluvial Systems 2020)

Site A4

Site A4 appears to consist of broken sections of a depression that funnel water from localised rainfall events (Figure 6.5). It does not appear that the depression holds water for any length of time, and any available water would be temporary; that is, it is likely to dry up within days without further rainfall.

The depression does not appear that it would provide adequate flow to provide for fish passage, or habitat opportunities.

Figure 6.5 Site A4 (from Geomorphology Assessment; Fluvial Systems 2020)

Site A5

Site A5 is approximately 2.0 km downstream of Site A2. Here, the feature appears to consist of broken sections of a drainage depression (Figure 6.6). Site A5 would be unlikely to provide adequate flow beyond the duration of a rainfall event. There is a complete lack of fish habitat

at Site A5 and immediately upstream at Site A3, suggesting this section of the waterway does not provide for fish passage.

Due to the lack of a channel with defined bed and banks, no riparian vegetation, lack of fish habitat or passage opportunities, Site A5 is not considered a waterway providing for fish passage.

Figure 6.6 Site A5 (from Geomorphology Assessment; Fluvial Systems 2020)

Sites A6, A7, and A8

Sites A6, A7, and A8 appear to be a drainage / overland flow corridor that lacks the features of a waterway providing for fish passage (Figure 6.7). There are no defined bed and banks. These sites would not provide adequate flow beyond an immediate rainfall event. There are no fish habitat or fish passage opportunities.

The mapped feature from Site A6 through to Site A8 does not exhibit any of the qualities of a waterway as defined by DAF, and as such, is not considered a waterway providing for fish passage.

Figure 6.7 Sites A6, A7, and A8 (from Geomorphology Assessment; Fluvial Systems 2020)

Site A9

Site A9 appears to be a drainage feature lacking the features of a waterway providing for fish passage (Figure 6.8). The drainage feature is flat, with no defined bed and banks. Terrestrial vegetation can be seen growing across the feature. This section of the mapped waterway would not provide adequate flow beyond an immediate rainfall event. There are no fish habitat or fish passage opportunities at this site, or at sites further upstream.

Due to the lack of a channel with defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Site A9 is not considered a waterway providing for fish passage.

Figure 6.8 Site A9 (from Geomorphology Assessment; Fluvial Systems 2020)

Site D5

The assessment by DAF found Site D5 represents a waterway providing fish passage through defined bed and banks as visible on the provided imagery.

Our assessment of Site D5 found the site is a drainage feature lacking the features of a waterway providing for fish passage (Figure 6.9). This section of the mapped feature would not provide adequate or extended flow beyond an immediate rainfall event. The drainage feature does not provide fish habitat opportunities. Terrestrial vegetation can be seen growing across the feature.

The drainage feature is not well formed and appears to be broken and discontinuous. The feature does not appear to have continuous defined bed and banks.

The mapped feature does not exhibit the qualities of a waterway as defined by DAF, and as such, is not considered a waterway providing for fish passage. This was confirmed during our recent field assessment (see Appendix B).

Figure 6.9 Site D5 (from site inspections; Whitehaven Coal 2021)

Site A10

The assessment by DAF found Site A10 represents a waterway providing fish passage, as it had a defined bed and banks as visible on the provided imagery.

Our assessment of Site A10 found this section of the waterway appears as a wide, deep channel that may provide fish passage opportunities during periods of flow from upstream catchments (Figure 6.10). There appears to be a defined bed and banks at both sites. The width and gentle grade suggest flow may be slow enough to allow for an extended period of flow. Aquatic habitat features, including large woody debris and depressions, are present.

The mapped feature at Site A10 exhibits qualities of a waterway as defined by DAF, and may be considered a waterway providing for fish passage.

Figure 6.10 Site A10 (from Geomorphology Assessment; Fluvial Systems 2020)

Site U1

The assessment by DAF found Site U1 to be a waterway providing fish passage, including:

- a defined bed and banks as visible on the provide imagery, and
- an extended period of flow as evidenced by the presence of standing water.

Our assessment found Site U1 is a waterway providing for fish passage (Figure 6.11). The mapped feature has defined bed and banks. In May 2019, there appears to have been significant flow to allow fish passage through this section of the waterway. The running water does not appear to be turbulent, suggesting water velocity is slow enough to allow an extended period of flow. Additionally, fish have been captured during previous fish surveys at this site (see Section 3.2.1 for details.)

The mapped feature at Site U1 exhibits qualities of a waterway providing for fish passage, as defined by DAF.

Figure 6.11 Site U1 (from site inspections; Whitehaven Coal 2021)

Site A11

This section of the waterway appears as a wide, deep channel that may provide fish passage opportunities during periods of flow from upstream catchments (Figure 6.12). There appears to be a defined bed and banks at both sites. It is a waterway providing for fish passage.

Figure 6.12 Site A11 (from Geomorphology Assessment; Fluvial Systems 2020)

Site 2 and Site 3

The assessment by DAF found Sites 2 and 3 have the features of a waterway providing fish passage, including:

- defined bed and banks as visible in aerial photographs (Queensland Globe), and

- an extended period of flow as evidenced by the presence of a green swath of grass along the waterway bed.

Our assessment of Sites 2 and 3 found the sites appear to be located in the vicinity of a rail bridge crossing, immediately downstream from Site A11 (Figure 6.13). The feature at Site 2 appears to be a wide flat channel, with a low bank. Terrestrial vegetation is growing across the feature.

The images of these sites do not allow for an adequate assessment to determine if these sites are a waterway providing for fish passage. However, our assessments of sites upstream and downstream of Site 2 and 3 in February 2022 found this section of the mapped waterway met the DAF requirements to be classified as a waterway providing for fish passage (see Appendix B).

Figure 6.13 Site 2 and Site 3 (from site inspections; Whitehaven Coal 2021)

Site A12

This section of the waterway appears as a deep channel that may provide fish passage opportunities during periods of flow from upstream catchments (Figure 6.14). There appears to be a defined bed and banks with overhanging vegetation, offering habitat opportunities during periods of flow. It is therefore a waterway providing for fish passage.

Figure 6.14 Site A12 (from Geomorphology Assessment; Fluvial Systems 2020)

Central Unnamed Waterway

Site 7 (FD1)

The assessment by DAF found the farm dam itself at Site 7 (and also described separately as Site FD1) is not a waterway providing fish passage. However, they suggested there is evidence of a feature entering the dam from the bank opposite to the photographer's position in Figure 6.15.

Our assessment of Site 7 (identified as being the same dam as Site FD1) found the site is a large, constructed dam (Figure 6.15 and Figure 6.16). The dam appears to have a moderately steep bank, approximately 3 m in height above the water level in the dam. Vegetation surrounding the dam appears to be terrestrial grasses with some shrubs set further back from the dam edge. There is evidence of a feature opposite to the photographer's position in the below image (Figure 6.15); however, DAF appear to be referencing a small eroded drainage feature (lacking a defined bed and banks), that conveys flows during rainfall events and would not likely provide adequate flow other than in times of localised rainfall.

While the dam may provide suitable fish habitat, the high dam walls likely act as a barrier to fish passage and restrict connectivity to any potential habitat opportunities upstream and downstream. Further, our assessment indicates a lack of fish passage opportunities immediately downstream of Site 7 (see description of Sites 6 and 5, below).

Figure 6.15 Site 7 dam, located at the upstream limit of the central unnamed waterway (from site inspections; Whitehaven Coal 2021)

Figure 6.16 Site FD1, constructed dam (Photos from EIS; ESP 2021)

Figure 6.17 Aerial image of Site 7 (FD1) (from QLD Globe)

Site 6 and Site 5

The waterway assessment by DAF found little evidence of a waterway providing for fish passage at Site 5 (Figure 6.19). Their assessment of Site 6 was inconclusive, and they were unable to make a determination of this features role in fish passage (Figure 6.18).

Our assessment found Site 6 and Site 5 are in relatively flat paddocks. The paddocks are likely to convey flows during rainfall events, with a small (~0.5 m wide) flow path/drainage line visible in places, particularly at Site 6. However, the drainage feature at Sites 6 and 5 lacks a defined bed and banks and is not continuous at either site. Vegetation appears to be dominated by terrestrial grasses.

The mapped feature at Sites 6 and 5 do not exhibit any of the qualities of a waterway as defined by DAF; and as such, are not considered to be waterways providing for fish passage.

Figure 6.18 Site 6 (Photo from site inspections; Whitehaven Coal 2021)

Figure 6.19 Site 5 (Photo from site inspections; Whitehaven Coal 2021)

Sites B1 and B2

The assessment by DAF found Site B2 may represent a waterway providing fish passage due to defined bed and banks as visible in the provided imagery, but also suggested greater information is required at Sites B1 and B2 to make a determination of this features role in fish passage (Figure 6.20).

Our assessment found Sites B1 to B2 are drainage depressions or gullies and lack features of a waterway providing for fish passage. There appears to be some erosion along the edges of some drainage channels, particularly at Site B1, which is visible in aerial photography (Figure 6.21). However, these sites do not have a continuous defined bed and banks and appear to be broken sections of a drainage gully. The drainage depression would not likely provide adequate flow other than in times of localised rainfall.

A return visit to Site B2 during the February 2022 site surveys also found Site B2 was a wide flat drainage gully with no standing water and no indications that the site held water for an extended period (see Site 72 in Appendix B for a full description).

Due to the lack of a channel with defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Sites B1 and B2 are not considered a waterway providing for fish passage.

Figure 6.20 Sites B1 and B2 (from Geomorphology Assessment; Fluvial Systems 2020)

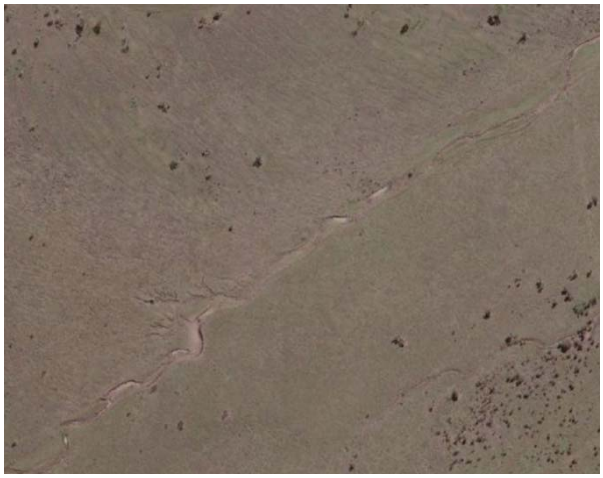


Figure 6.21 Aerial image of Sites B1 and B2 (from QLD Globe)

Site 1

DAF found Site 1 possesses the features necessary to be considered a waterway providing fish passage, through:

- a defined bed and banks, and
- an extended period of flow as evidenced by the presence of standing water in the dam by-wash area.

Our assessment of Site 1 found the site contains a small depression adjacent to a dam wall. There was a small pool of water within the depression in September 2021 (Figure 6.22). It does not appear that the depression would hold water for any length of time and that the water was only temporary; that is, it is likely to dry up within days without further rainfall. Standing water in a shallow pool does not indicate an extended period of flow. There are no shade or habitat opportunities within the depression, and the standing water appears turbid. Any flows through this reach of the mapped feature are likely to be short-lived and insufficient to maintain aquatic ecological processes.

There appears to be a drainage depression, or gully, leading to the small pool of water. The depression is not holding water and appears to contain terrestrial vegetation. The banks of this drainage feature do not appear to be continuous or well defined. The drainage depression would not likely provide adequate flow other than in times of localised rainfall. Due to the lack of a channel with continuously defined bed and banks, no riparian vegetation, and insufficient flow to maintain aquatic ecological processes, Site 1 is not considered a waterway providing for fish passage.

Figure 6.22 Site 1 (Photo from site inspections; Whitehaven Coal 2021)

Site FD2

The assessment by DAF found the farm dam itself is not a waterway providing fish passage, but there is evidence of a feature entering the dam from upstream on Queensland Globe imagery. DAF considered that fish movement past this feature is likely during periods of high flows.

Our assessment found Site FD2 is a large, constructed dam. The dam walls are approximately 4 m in height, and act to restrict connectivity to upstream and downstream reaches. Aquatic plants are present in the dam. Additionally, fish have been captured during previous fish surveys at this site (see Section 3.2.1 for details). While the dam provides suitable fish habitat, the high dam walls act as a barrier, creating a lack of connectivity upstream and downstream.

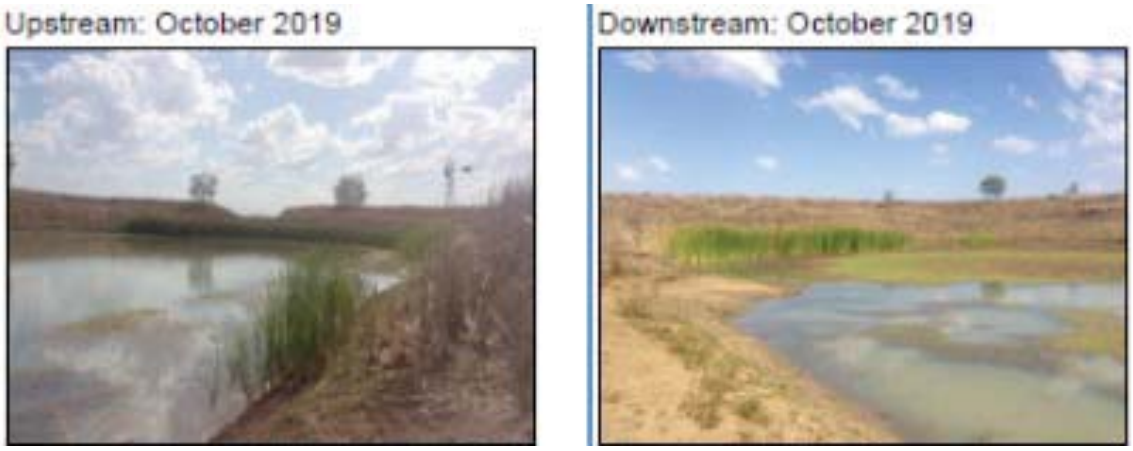


Figure 6.23 Site FD2 (Photo from EIS; ESP 2021)

Sites B3 and B4

Sites B3 and B4 are drainage depressions or gullies and lack features of a waterway providing for fish passage (Figure 6.24). These sites do not have a defined bed and banks, and do not appear that they would provide adequate flow other than in times of localised rainfall. There appears to be some erosion along the edges of some drainage channels; however, this is likely from short high velocity flows during periods of high localised rainfall.

The mapped feature at Sites B3 and B4 did not exhibit any of the qualities of a waterway as defined by DAF, and as such, is not considered a waterway providing for fish passage.

Figure 6.24 Sites B3 and B4 (Photos from Geomorphology Assessment; Fluvial Systems 2020)

Sites B5 and B6

The assessment by DAF found the feature at Site B5 represents a waterway providing fish passage due to defined bed and banks as visible on the provide imagery. Site B6 was not considered a waterway by DAF.

Our assessment found Sites B5 and B6 are drainage depressions, or gullies, lacking the features of a waterway providing for fish passage (Figure 6.25). The drainage feature presents as a slight depression forming a gully that likely directs overland flows for a short duration. The drainage feature does not provide fish passage or habitat opportunities, and does not appear to have an unbroken, continuous defined bed and banks. This section of the mapped feature would not provide adequate flow beyond an immediate rainfall event. Terrestrial vegetation can be seen growing across the feature.

Figure 6.25 Sites B5 and B6 (Photos from Geomorphology Assessment; Fluvial Systems 2020)

Site FD3

The assessment by DAF found the farm dam itself is not a waterway providing fish passage. However, they stated that there is evidence of a feature entering the dam from upstream on Queensland Globe imagery. DAF suggested that fish movement past this feature is likely during periods of high flows.

Our assessment found Site FD3 is a large, constructed dam (Figure 6.26). The dam appears to have a moderately steep bank, approximately 3 m in height above the water level in the dam.

While the dam may provide fish habitat opportunities, the relatively steep, high dam walls act as a barrier to fish passage, reducing connectivity upstream and downstream.

Figure 6.26 Site FD3, constructed dam (Photos from EIS; ESP 2021)

Sites B7 and B8 (inc. Site U2)

The assessment by DAF found Sites B7, B8 and U2 represents a waterway providing fish passage due to defined bed and banks as visible on the provided imagery.

Our assessment found Sites B7 and B8 are drainage depressions or gullies, lacking the features of a waterway providing for fish passage (Figure 6.27). The drainage feature does not appear to have continuous, defined bed and banks and instead appears to be a drainage line for directing overland flows. This section of the mapped feature would not provide adequate flow beyond an immediate rainfall event. The drainage line at Site U2, while more defined than at Sites B7 and B8, appears to be a discontinuous drainage gully with eroded banks; typical of a feature that experiences intermittent high velocity flows immediately following rainfall events, and not of a waterway that would support extended periods of flow that would offer fish passage opportunities (Figure 6.28).

Due to the lack of a channel with no continuous defined bed and banks, no riparian vegetation, lack of fish habitat or passage opportunities, Sites B7, B8 and U2 are not considered a waterway providing for fish passage.

Figure 6.27 Site B7 and B8 (Photos from Geomorphology Assessment; Fluvial Systems 2020)

Figure 6.28 Sites B8 and U2 (Photos from site inspections; Whitehaven Coal 2021)

Site D2

Site D2 is a drainage feature / overland flow path (Figure 6.29). The drainage feature does not provide fish passage or habitat opportunities and does not appear to have defined bed and banks. This section of the mapped feature would not provide adequate flow beyond an immediate rainfall event. Terrestrial vegetation can be seen growing across the feature.

Due to the lack of a channel with defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Site D2 is not considered a waterway providing for fish passage.

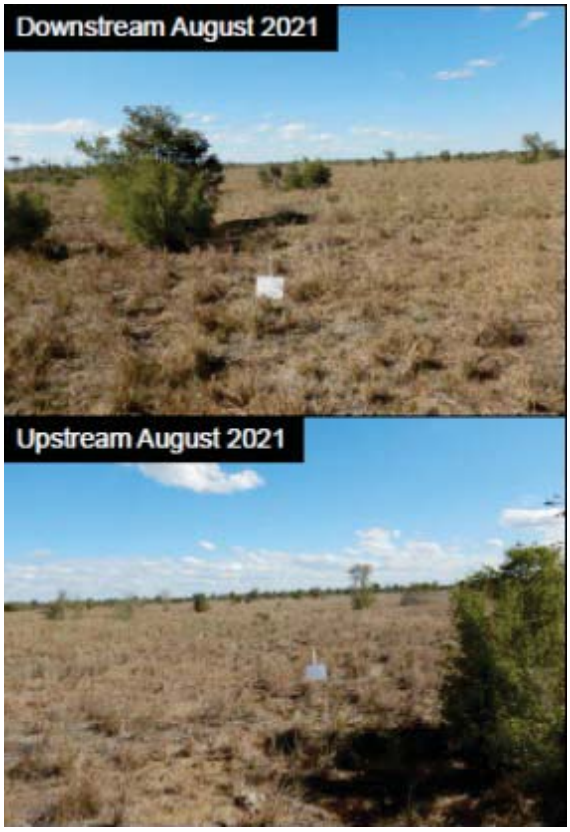


Figure 6.29 Site D2 (Photos from site inspections; Whitehaven Coal 2021)

Site U7

The assessment by DAF found this site possesses the features necessary to be considered a waterway providing fish passage by presenting defined bed and banks as visible on the provided photography.

Our assessment found Site U7 is a drainage depression, or gully, lacking the features of a waterway providing for fish passage (Figure 6.30). The upstream image of Site U7 presents the feature as containing broken, discontinuous sections of a drainage depression. In the downstream image, there appears to be some erosion along the outside bank of the drainage gully, indicative of high velocity water eroding the bank as the water sweeps around the bend in the gully. Erosion on the outside bend of a drainage gully can be indicative of a channel that is either; experiencing abrupt periods of high velocity flows; that is not well defined; and does not support riparian vegetation that would protect the feature from erosion.

The drainage feature likely directs intermittent, localised flows, and would not provide extended or persistent flows outside of a localised rainfall event. The drainage feature would likely not provide fish passage or habitat opportunities outside of an immediate localised rainfall event.

Figure 6.30 Site U7, showing upstream and downstream in October 2019 (Photos from EIS; ESP 2021)

Site B9

Site B9 is a drainage depression (Figure 6.31). The depression does not have a continuously defined bed and banks, and would not provide adequate flow beyond an immediate rainfall event. The drainage feature does not provide fish passage or habitat opportunities, and lacks the features of a waterway providing for fish passage. Terrestrial vegetation, particularly grasses, can be seen growing across the depression.

The mapped feature at Site B9 does not exhibit any of the qualities of a waterway as defined by DAF, and as such, is not considered a waterway providing for fish passage.

Figure 6.31 Site B9, showing upstream and downstream of the assessment site (Photos from Geomorphology Assessment; Fluvial Systems 2020)

Site B10 and B11

This section of the waterway appears as a wide, deep channel that may provide fish passage opportunities during periods of flow from upstream catchments (Figure 6.32). There appears to be a defined bed and banks at both sites. However, the channel is narrow with high banks,

suggesting flow velocity may be high and may not provide adequate flow beyond an immediate rainfall event.

The mapped feature at Sites B10 and B11 exhibits some qualities of a waterway as defined by DAF, and may be considered a waterway providing for fish passage.

Figure 6.32 Sites B10 and B11 (Photos from Geomorphology Assessment; Fluvial Systems 2020)

Southern Unnamed Waterway

Site FD4

The assessment by DAF found Site FD4 was not a waterway providing fish passage and that there is no evidence of a feature entering the dam from upstream or leaving downstream visible on Queensland Globe imagery.

Site FD4 is a large, constructed dam (Figure 6.33). Dam walls are approximately 5 m in height. Aquatic vegetation is growing within the dam, providing fish habitat opportunities. Fish have been captured during previous fish surveys at this site (see Section 3.2.1 for details). However, the steep, high dam walls act as a barrier to fish passage and prevent connectivity to upstream and downstream reaches.

Figure 6.33 Site FD4, constructed dam (Photos from EIS; ESP 2021)

Sites C1 to C5

The assessment by DAF of Sites C2, C4, and C5 found:

- Site C2 is unlikely to represent a waterway providing for fish passage, and
- Sites C4 and C5 may represent a waterway providing fish passage due to presence of a defined bed and banks as visible on the provide imagery. However, greater information is required to determine this feature's role in fish passage.

Our assessment found Sites C1 through to C5 appear to be a drainage depression that lack the features of a waterway providing for fish passage (Figure 6.34 and Figure 6.35). There are no continuous defined bed and banks, and the feature appears to be broken sections of a drainage line. These sites do not appear that they would provide adequate flow beyond an immediate rainfall event. There are no fish habitat or fish passage opportunities.

The mapped feature from Site C1 through to Site C5 do not exhibit any of the qualities of a waterway as defined by DAF, and as such, is not considered a waterway providing for fish passage.

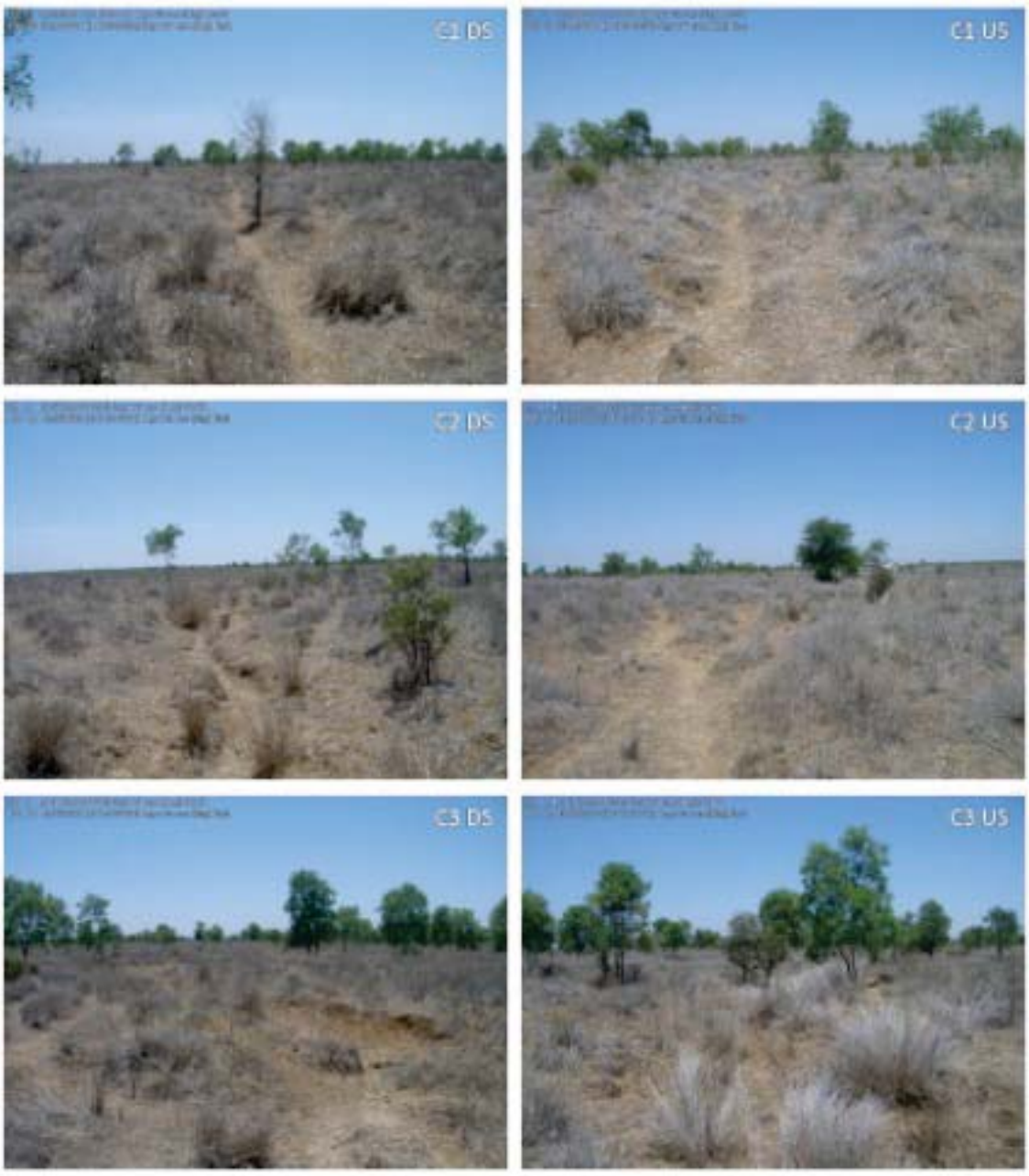


Figure 6.34 Sites C1, C2, C3 (Photos from Geomorphology Assessment; Fluvial Systems 2020)

Figure 6.35 Sites C4 and C5 (Photos from Geomorphology Assessment; Fluvial Systems 2020)

Site U5

Site U5 is a drainage depression, immediately downstream from Site C6. The drainage depression does not have defined bed or banks and appears that the mapped feature would not provide adequate flow beyond an immediate rainfall event (Figure 6.36). The drainage depression at Site U5 is not a waterway providing habitat or fish passage opportunities.

Due to the lack of a channel with defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Site U5 is not considered a waterway providing for fish passage.

Figure 6.36 Site U5, showing upstream and downstream in October 2019 (Photos from EIS; ESP 2021)

Site C6

Site C6 (R18 in Olive Downs EIS) is a drainage depression that lacks the features of a waterway providing for fish passage. There are no defined bed and banks or suitable habitat features (Figure 6.37 and Figure 6.38).

The mapped feature does not exhibit any of the qualities of a waterway as defined by DAF, and as such, is not considered a waterway providing for fish passage.

Figure 6.37 Site C6 (Photos from Geomorphology Assessment; Fluvial Systems 2020)

Figure 6.38 Site R18 (Photos from Olive Downs EIS, DPM Envirosciences 2018)

Site R20

Site R20 is an ephemeral drainage line that lacks the features of a waterway providing for fish passage. There are no defined bed and banks or suitable habitat features (Figure 6.39).

The mapped feature does not exhibit any of the qualities of a waterway as defined by DAF, and as such, is not considered a waterway providing for fish passage.

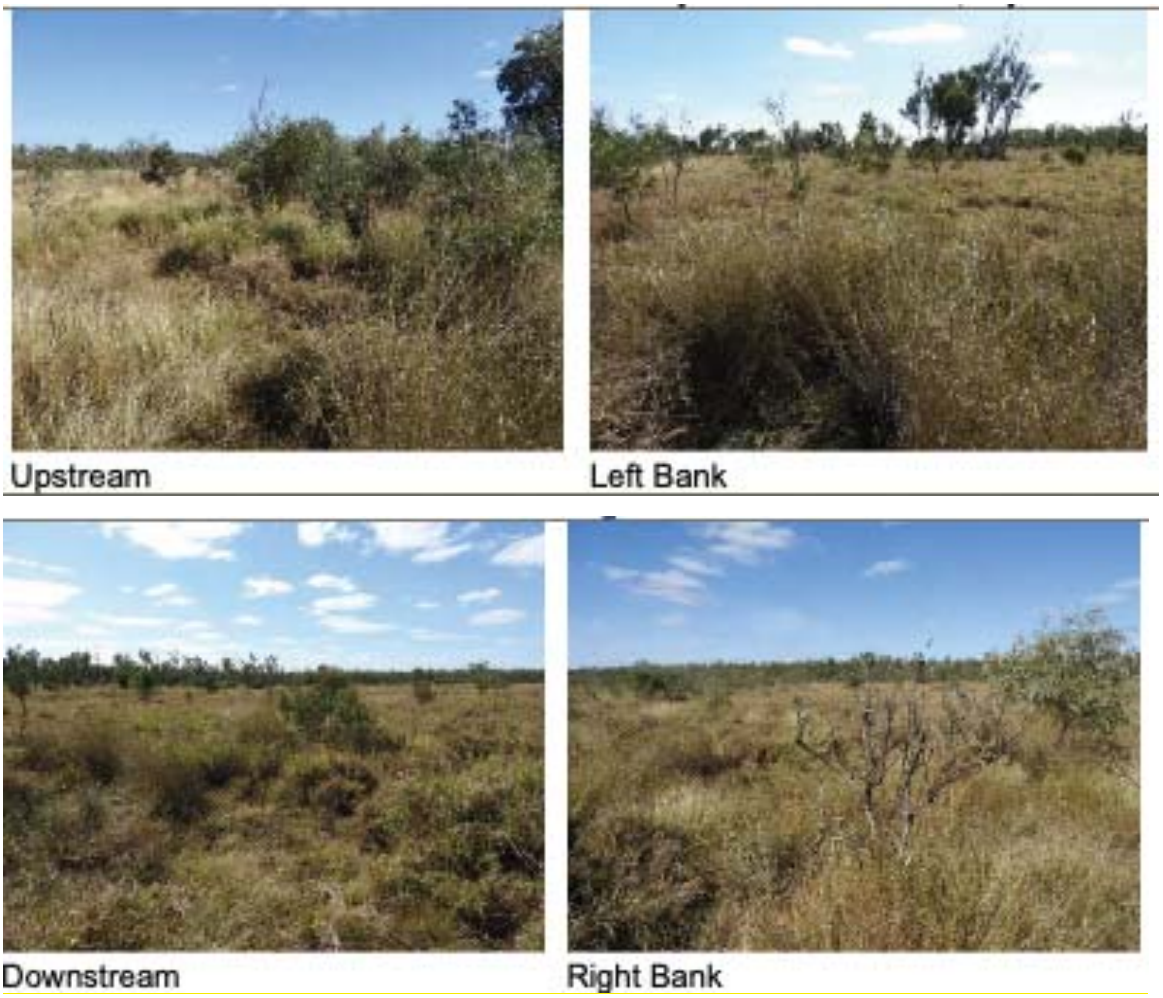


Figure 6.39 Site R20 (Photos from Olive Downs EIS, DPM Enviroscences 2018)

Site R22

Site R22 is an ephemeral drainage depression that lacks the features of a waterway providing for fish passage. There are no defined bed and banks or suitable habitat features (Figure 6.40).

The mapped feature does not exhibit any of the qualities of a waterway as defined by DAF, and as such, is not considered a waterway providing for fish passage.

Figure 6.40 Site R22 (Photos from Olive Downs EIS, DPM Enviroscienses 2018)

Site C7

Site C7 is a drainage depression that lacks the features of a waterway providing for fish passage. There are no defined bed and banks or suitable habitat features (Figure 6.41).

Due to the lack of a channel with defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Site C7 is not considered a waterway providing for fish passage.

Figure 6.41 Site C7 (Photos from Geomorphology Assessment; Fluvial Systems 2020)

Site D6

The assessment by DAF found Site D6 is unlikely to represent a waterway providing for fish passage.

Our assessment found Site D6 is a drainage corridor that lacks the features of a waterway providing for fish passage (Figure 6.42). There are no defined bed and banks or suitable habitat features.

The mapped feature does not exhibit any of the qualities of a waterway as defined by DAF, and as such, is not considered a waterway providing for fish passage.

Figure 6.42 Site D6 (Photos from site inspections; Whitehaven Coal 2021)

Site FD7

Site FD7 is a large, constructed dam (Figure 6.43). The downstream side of the dam appears to have a moderately steep bank of approximately 3 m in height above the water level in the dam. Vegetation surrounding the dam appears to be terrestrial grasses with some shrubs and trees set further back from the dam edge.

While the dam may provide fish habitat opportunities, there is a lack of connectivity to suitable habitat upstream and particularly downstream due to the high dam wall.

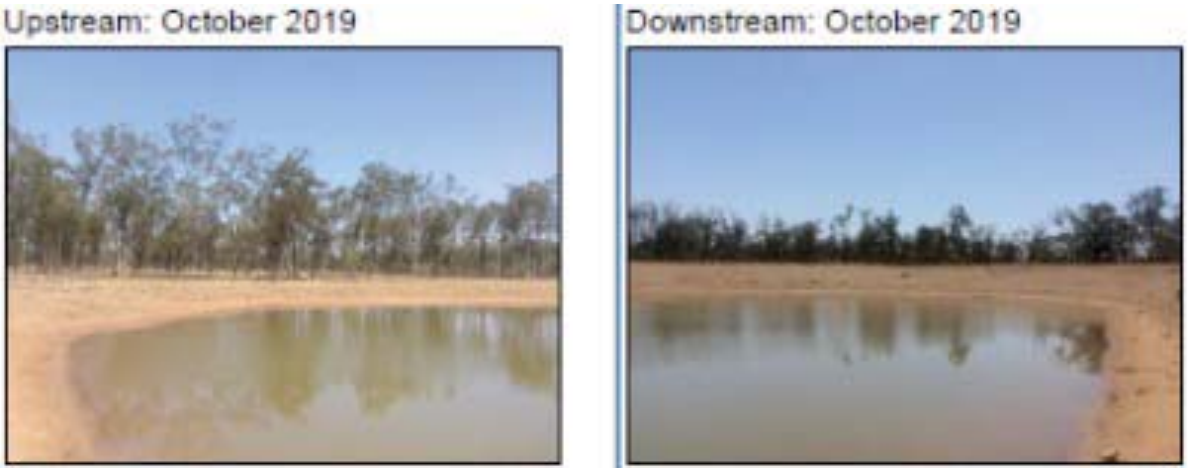


Figure 6.43 Site FD7, constructed dam, showing upstream and downstream in October 2019 (Photos from EIS; ESP 2021)

Site U6

The assessment by DAF found Site U6 is unlikely to represent a waterway providing for fish passage.

Site U6 is a drainage depression or gully that lacks the features of a waterway providing for fish passage (Figure 6.44). While there is some erosion along the edges of a broken gully, there is no continuous bed and banks, or suitable habitat features.

The mapped feature does not exhibit any of the qualities of a waterway as defined by DAF, and as such, is not considered a waterway providing for fish passage.

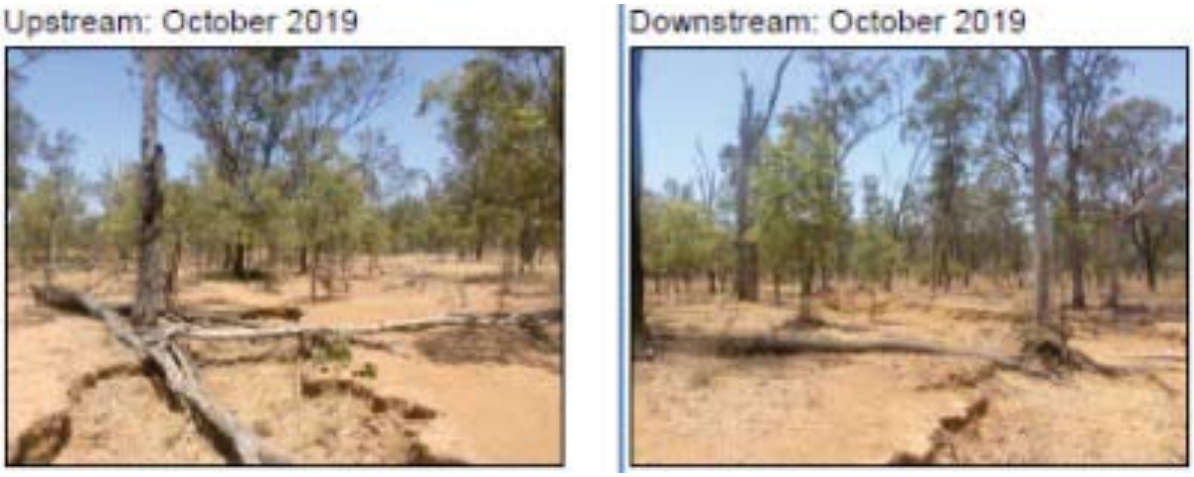


Figure 6.44 Site U6 (Photos from EIS; ESP 2021)

Site R15

Site R15 is an ephemeral drainage line that lacks the features of a waterway providing for fish passage. There are no defined bed and banks or suitable habitat features (Figure 6.45).

The mapped feature does not exhibit any of the qualities of a waterway as defined by DAF, and as such, is not considered a waterway providing for fish passage.

Figure 6.45 Site R15 (Photos from Olive Downs EIS, DPM Enviroscience 2018)

Site R21

Site R21 is an ephemeral drainage line that lacks the features of a waterway providing for fish passage. There are no defined bed and banks or suitable habitat features (Figure 6.46).

The mapped feature does not exhibit any of the qualities of a waterway as defined by DAF, and as such, is not considered a waterway providing for fish passage.

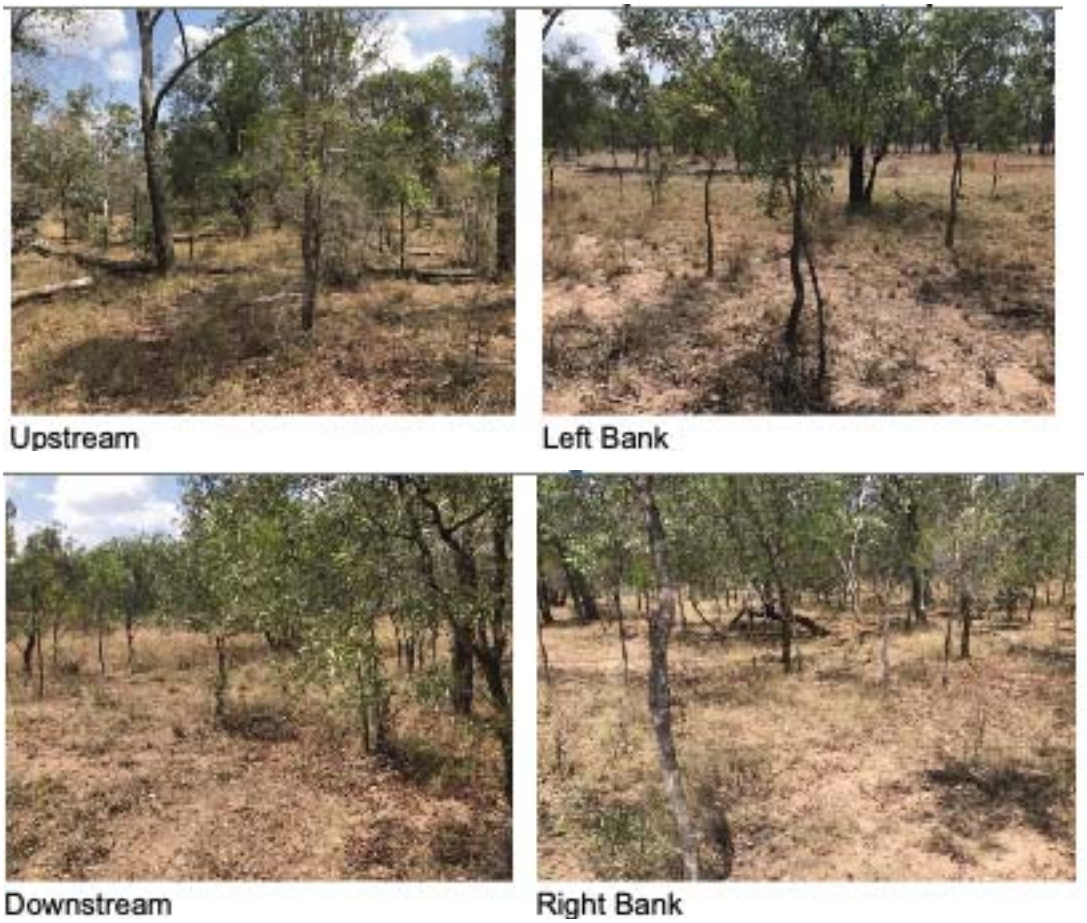


Figure 6.46 Site R21 (Photos from Olive Downs EIS, DPM Envirosciences 2018)

Site LW5

Site LW5 is a large, constructed dam (Figure 6.47). The dam walls are approximately 3 m in height, and act to restrict connectivity to upstream and downstream reaches. Aquatic plants are present in the dam. There is no riparian vegetation or shading, and a lack of habitat features. There appears to be no connectivity to upstream and downstream reaches.

Figure 6.47 Site LW5, constructed dam, showing upstream and downstream in October 2019 (Photos from EIS; ESP 2021)

Site C8 through to C13

Sites C8 through to C13 appear to be a drainage gully that lack the features of a waterway providing for fish passage (Figure 6.48, Figure 6.49 and Figure 6.50). These sites do not appear that they would provide adequate flow beyond an immediate rainfall event. There are no fish habitat or fish passage opportunities. The gully at Site C13 appears to narrow, deepen and become steeper, suggesting high velocity flow as it travels down a steep gradient toward the Isaac River.

The mapped feature from Site C8 through to Site C13 does not exhibit any of the qualities of a waterway as defined by DAF, and as such, is not considered a waterway providing for fish passage.

Figure 6.48 Sites C8 and C9 (Photos from Geomorphology Assessment; Fluvial Systems 2020)

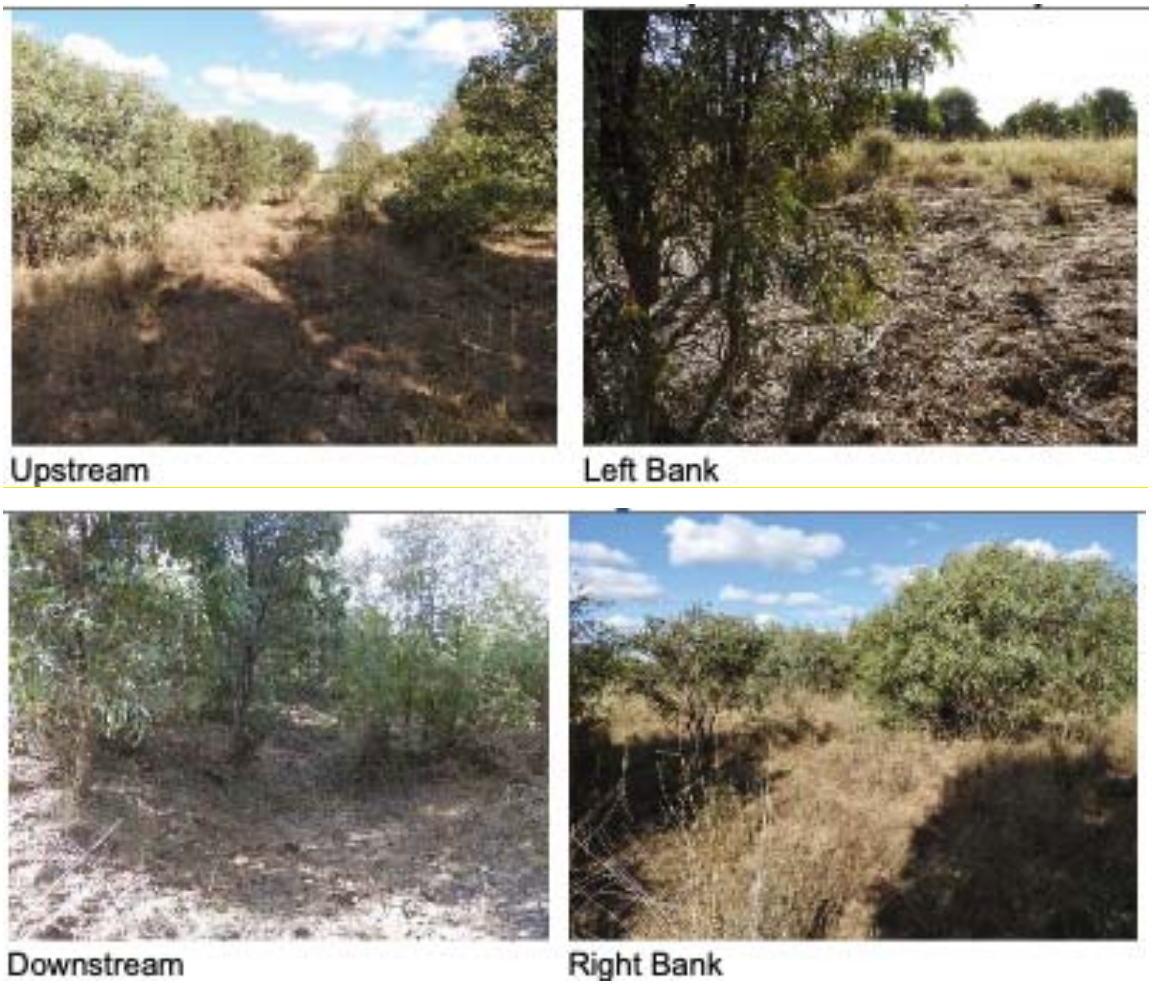


Figure 6.49 Site R7 (Photos from Olive Downs EIS, DPM Enviroscience 2018)

Figure 6.50 Site C10, C11, C12, and C13 (Photos from Geomorphology Assessment; Fluvial Systems 2020)

Unmapped Waterways

Site U4

The assessment by DAF found that Site U4 possesses the features necessary to be considered a waterway providing fish passage, through:

- defined bed and banks as visible on the provided photography, and
- an extended period of flow as evidenced by the presence of standing water.

Our assessment found Site U4 is an unmapped drainage depression with highly eroded channel features (Figure 6.51). In October 2019 there was a small pool of water within the depression, about 2 m wide at its widest point. However, it appears that this pool was small and shallow and would not hold water for any length of time and that the water was only temporary; that is, it is likely to dry up within days without further rainfall.

While the upstream image from October 2019 does appear to show a defined bed and banks on the eroding outside bend of a channel, the image from May 2019 captures a larger area of the feature and indicates the channel is made up of broken sections of a drainage feature or gully.

There is little shade or habitat opportunities within the depression, and the standing water was very turbid. Flows through this mapped feature are likely to be high velocity and short-lived.

Additionally, no fish or macrocrustaceans were captured at this site during fish surveys for the Draft EIS in May 2019 (the site was dry in October 2019) (ESP 2021; see Section 3.2.1 for fish survey details). This indicates a lack of connectivity to downstream fish habitat, and that the feature is not providing for fish passage.

Site U4 does not possess the features necessary to be considered a waterway providing fish passage.

Upstream: May 2019	Upstream: October 2019
	

Figure 6.51 Site U4 (ESP 2021)

Site LW3

Site LW3 is a constructed ‘turkey’s nest’ dam with 7 m high dam walls (Figure 6.52). The dam wall heights are a barrier to fish passage and restrict any possible fish movement from

downstream. The water is highly turbid. There is no riparian vegetation, no shading, and a lack of habitat features. There is no connectivity to upstream and downstream reaches. There is no evidence of a waterway providing for fish passage at this location.

Figure 6.52 Site LW3, constructed dam (Photos from EIS; ESP 2021)

Site D4

Due to the lack of a channel with continuously defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Site D4 is not considered a waterway providing for fish passage (Figure 6.53). This is consistent with the assessment by DAF.

Figure 6.53 Site D4 (from site inspections; Whitehaven Coal 2021)

Site D7

Site D7 is an unmapped drainage feature. The feature appears to consist of broken sections of a depression that funnels water from localised rainfall events (Figure 6.54). It does not appear that the depression holds water for any length of time and that available water would be temporary; that is, it is likely to dry up within days without further rainfall.

The depression does not have continuous bed and banks, nor does it appear that it would provide adequate flow to provide for fish passage, or habitat opportunities.

Figure 6.54 Site D7 (Photos from site inspections; Whitehaven Coal 2021)

Site FD5

The assessment by DAF found the farm dam itself is not a waterway providing fish passage. However, they suggested there is evidence of a feature entering the dam from upstream as well as visible downstream by-wash visible on Queensland Globe imagery. DAF suggest that fish movement past this feature is likely during periods of high flows.

Our assessment found Site LW3 is a constructed ‘turkey’s nest’ dam with high dam walls (Figure 6.55). The dam wall heights are a barrier to fish passage and would restrict fish movement from downstream. There is no riparian vegetation, no shading, and a lack of habitat features. There is no connectivity to upstream and downstream reaches.

There are no mapped waterways within the vicinity of this site (see Section 2.1.1.1 for details).

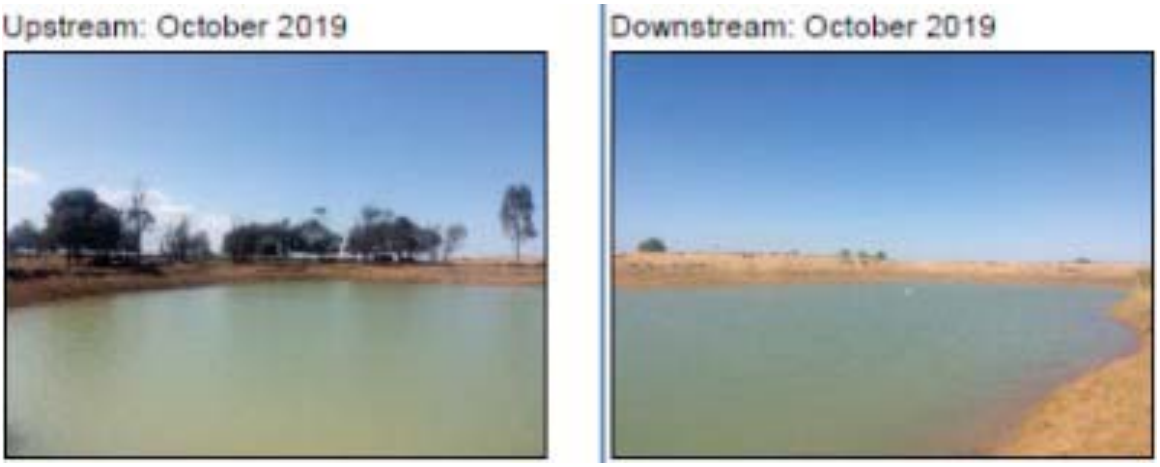


Figure 6.55 Site FD5, constructed dam (Photos from EIS; ESP 2021)

Site LW2

Site LW2 is a dry constructed dam (Figure 6.56). There is no riparian vegetation and no shading. There does not appear to be any fish habitat.

There are no mapped waterways within the vicinity of this site (see Section 2.1.1.1 for details).

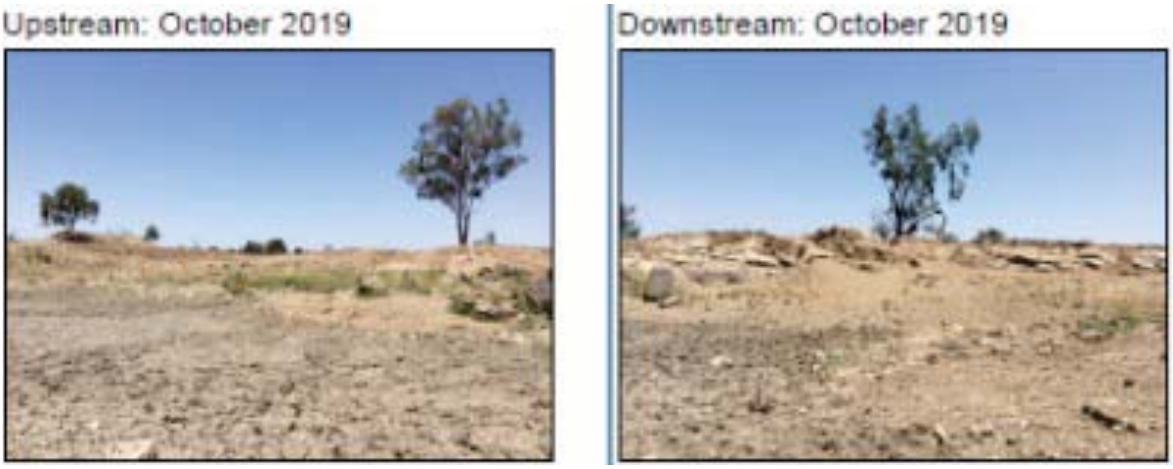


Figure 6.56 Site LW2 (Photos from EIS; ESP 2021)

Site LW7

Site LW7 appears to be a constructed dam (Figure 6.57). The dam has steep dam walls, approximately 8 m in height, which would act as a barrier to fish movement. There are no habitat features and no aquatic vegetation.

Figure 6.57 Aquatic habitat features at site LW7, showing a) upstream and b) downstream (Photos from EIS; ESP 2021)

Appendix B February 2022 Field Site Assessment Results

Northern Unnamed Waterway

Site 79 (U3)

Site 79 (U3 in previous assessments; see Appendix A) is a drainage gully passing through a dirt road. A pipe culvert (~40 cm diameter) passes under the road but does not start within or discharge to a channel with defined bed and banks. The upstream gully banks are broken and undulating with several flow paths converging at the culvert entrance. Rocks have been placed on the outside of the bed as an erosion control. Downstream of the culvert, eroding banks are on the outside of a bend from high velocity flows, likely during periods of localised heavy rainfall.

The drainage gully is not well formed and has likely been created during periods of heavy localised rain events (Figure 6.58). It does not appear that flows would persist for any extended period.

Due to the lack of a channel with defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Site 79 is not considered a waterway providing for fish passage.

a)

b)

c)

d)

e)

f)

Figure 6.58 Site 79 (U3 in previous surveys) showing a) upstream, b) left bank, c) downstream, d) right bank, e) upstream culvert entrance, and f) downstream culvert entrance

Sites 166 and 165

Our assessment found Sites 166 and 165 are drainage depressions or gullies that lack features of a waterway providing for fish passage (Figure 6.59 and Figure 6.60). There appears to be some erosion along the edges of some of the depressions. However, these sections do not have a continuous defined bed and banks, and instead consist of broken sections of a drainage gully, particularly along straight sections of the channel. The drainage

depression at these sites would not flow other than in times of localised rainfall. Flow is not sufficient to maintain aquatic ecological processes. There was no evidence of aquatic flora or fauna presence at these sites, including a lack of dead sedges or evidence of aquatic fauna such as mollusc shells. Due to the lack of a channel with continuously defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Sites 166 and 165 are not considered waterways providing for fish passage.

a)

b)

c)

d)

e)

Figure 6.59 Site 166 showing a) upstream, b) left bank, c) downstream, d) right bank, and e) unconsolidated/cracking soils with no evidence of aquatic flora or fauna

a)

b)

c)

d)

e)

Figure 6.60 Site 165 showing a) upstream, b) left bank, c) downstream, d) right bank, and e) unconsolidated/cracking soils with no evidence of aquatic flora and fauna

Site 161

Site 161 is a drainage depression, immediately upstream of a 'turkey's nest' dam (Site 160). The drainage depression does not have continuously defined bed or banks, and there was no evidence that it would provide adequate flow beyond an immediate rainfall event (Figure 6.61). There was no riparian vegetation or fish habitat present. The drainage depression at Site 161 is not a waterway providing for fish passage.

a)

b)

c)

d)

e)

Figure 6.61 Site 161 showing a) upstream, b) left bank, c) downstream, d) right bank, and e) unconsolidated/cracking soils with no evidence of aquatic flora or fauna

Site 160

Site 160 is a constructed dam (Figure 6.62). The dam walls are approximately 10 m in height, and prevent connectivity, and there is no evidence of a waterway channel downstream of the dam (Figure 6.62e,f). The dam wall along the downstream extent of the dam extends away from the dam to the north, which appears designed to direct overland flows into the dam, but may also operate as the dam overflow. There is a drainage channel

that funnels overland flows into the dam. There is no riparian vegetation or shading, and a lack of habitat features. The dam at Site 160 acts as a barrier to fish passage.

a)

b)

c)

d)

e)

f)

Figure 6.62 Site 160 showing a) upstream of dam, b) left bank, c) downstream to dam, d) right bank, e) dam wall extending away from dam, and f) downstream of dam

Site 159 (A5)

Site 159 (A5 in previous assessments; see Appendix A) is downstream of the large dam wall at Site 160. The feature consists of a deep wide drainage depression, with no standing water

(Figure 6.63). The bed and banks are not well defined, are highly eroded, and consist of loose silty soil. Due to the high dam wall immediately upstream, Site 159 is unlikely to provide adequate flow beyond the duration of a rainfall event. Due to the lack of a channel with continuously defined bed and banks, no riparian vegetation, lack of fish habitat or passage opportunities, Site 159 is not considered a waterway providing for fish passage.

a)

b)

c)

d)

e)

f)

Figure 6.63 Site 159 showing a) upstream, b) left bank, c) downstream, d) right bank, e) unconsolidated/cracking soils, and f) a wider view of the feature, looking downstream

Site 80

Site 80 is a drainage depression passing through a dirt road (Figure 6.64). A cement pipe culvert (~40 cm diameter) passes under the road. The road is elevated above the natural ground level, and the pipe culvert is largely blocked with soil. The drainage feature at Site 80 is flat, with no defined bed and banks. Terrestrial vegetation can be seen growing across the feature. This section of the mapped waterway would not provide adequate flow beyond an immediate rainfall event. There is no fish habitat at this site, or at sites further upstream. Site 80 is not a waterway providing for fish passage.

a)

b)

c)

d)

e)

f)

Figure 6.64 Site 80 showing a) upstream, b) left bank, c) downstream, d) right bank, e) upstream culvert entrance, and f) downstream culvert entrance

Site 78 (A3)

Site 78 (A3 in previous assessments, see Appendix A) is a drainage gully. There is significant erosion along the edges of parts of the feature, particularly on the outside of bends (Figure 6.65). The highly eroded banks are likely to confine flows in times of localised rainfall. However, there was no evidence that flows were sufficient to maintain aquatic ecological processes.

The upstream section of Site 78 flattens out and does not have a continuous defined bed and banks. Due to the lack of a channel with continuously defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Site 78 is not a waterway providing for fish passage.

a)

b)

c)

Figure 6.65 Site 78 (A3) showing a) upstream, b) left bank, and c) downstream

Site 158

Site 158 is downstream of Site 78. Here, the feature consists of broken sections of a drainage depression, with no standing water (Figure 6.66). There is significant erosion in places, particularly on the outside of bends. The highly eroded banks are likely to confine flows, and a shallow depression within the gully, indicated by taller grasses, carries flow during rainfall events.

Site 158 is unlikely to provide adequate flow beyond the duration of a rainfall event. There is a complete lack of fish habitat at Site 158 and immediately upstream at Site 78, suggesting this section of the feature does not provide fish passage opportunities.

Due to the lack of a main channel with continuously defined bed and banks, no riparian vegetation, lack of fish habitat or passage opportunities, Site 158 is not considered a waterway providing for fish passage.

a)

b)

c)

d)

e)

f)

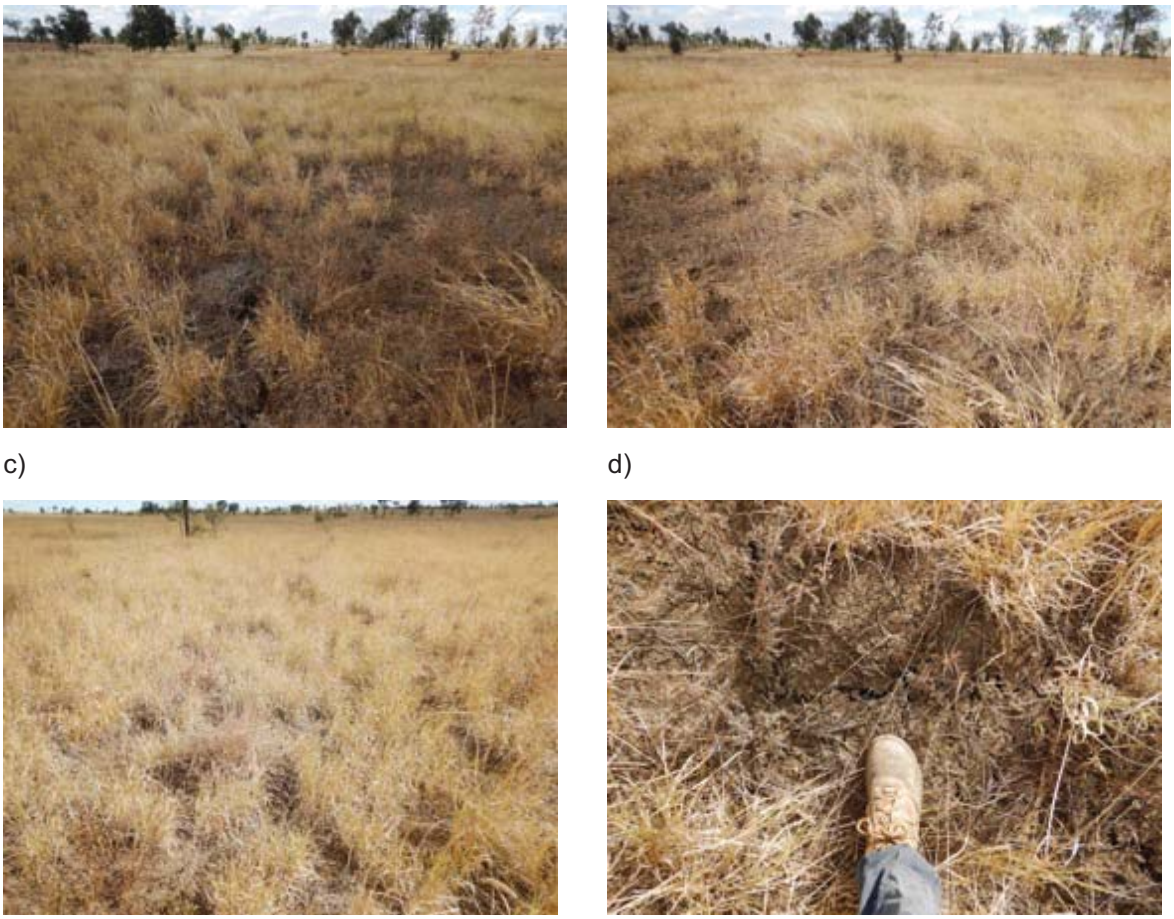
Figure 6.66 Site 158 showing a) upstream, b) left bank, c) downstream, d) right bank, e) main channel gully indicated by long grasses, and f) unconsolidated/cracks soils

Site 156

Site 156 is a flat drainage feature with no defined bed and banks (Figure 6.67). Terrestrial vegetation can be seen growing across the feature. This section of the mapped feature would not provide adequate flow beyond an immediate rainfall event. There are no fish habitat or fish passage opportunities at this site.

The lack of defined bed and banks, in combination with insufficient water availability to sustain basic aquatic ecological processes and habitats, and the lack of riparian vegetation, means this reach is not a waterway providing for fish passage.

a) b)



c) d)

Figure 6.67 Site 156 showing a) upstream, b) left bank, c) downstream, and d) unconsolidated/cracked soils

Site 77 (A4)

Site 77 (A4 in previous assessments; see Appendix A) is a flat drainage feature, with no defined bed and banks (Figure 6.68). A road cuts across the feature and the downstream section appears to have been graded to direct overland flows away from the road. Terrestrial vegetation can be seen growing across the feature.

This section of the mapped waterway would not provide adequate flow beyond an immediate rainfall event. There are no fish habitat or fish passage opportunities at this site.

This reach of the mapped feature is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.68 Site 77 showing a) upstream, b) left bank and road crossing, c) downstream, and d) right bank

Site 157

Site 157 is a wide drainage channel with highly eroded areas, particularly on the outside bends (Figure 6.69). The soil is silty and unconsolidated. A shallow depression within the gully would carry flows during rainfall events, but it is unlikely to provide adequate flow beyond the duration of a rainfall event. There is a complete lack of fish habitat, suggesting this section of the waterway does not provide fish passage opportunities.

Due to the lack of a main channel with continuously defined bed and banks, and lack of fish habitat or passage opportunities, Site 157 is not considered a waterway providing for fish passage.

a)

b)

c)

d)

e)

f)

Figure 6.69 Site 157 showing a) upstream, b) left bank, c) downstream, d) right bank, e) main channel gully indicated by long grasses, and f) unconsolidated/cracks soils

Sites 75 (A6) and 76 (A7)

Sites 75 and 76 (Sites A6 and A7, respectively, in previous assessments; see Appendix A) are homogonous with surrounding terrain, with no drainage feature present at either site. A search of the area failed to find a drainage feature present within 250 m of each site.

Due to the lack of a waterway with any waterway features, Sites 75 and 76 are not considered a waterway providing for fish passage (Figure 6.70 and Figure 6.71). This further suggests that there is no opportunity for fish passage from the downstream reaches of the mapped amber feature to the upstream mapped green tributaries.

a)

b)

c)

d)

Figure 6.70 Site 75 (A6) showing a) upstream, b) left bank, c) downstream, and d) right bank

a)

b)

c)

d)

e)

f)

Figure 6.71 Site 76 (A7) showing a) upstream, b) left bank, c) downstream, d) right bank, e) unconsolidated/cracks soils, and f) wider view of downstream terrain

Site 81 (A8)

No drainage feature was found at Site 81 (A8 in previous assessments; see Appendix A). A 1 km search along the fence line in a north-south direction failed to find any waterway features crossing the dirt track (Figure 6.72).

Due to the lack of a waterway with any waterway features, Site 81 is not considered a waterway providing for fish passage. This further reinforces that there is no opportunity for fish passage along large sections of the mapped amber feature.

a)

b)

c)

d)

Figure 6.72 Site 81 showing a) upstream, b) left bank with road crossing, c) downstream, and d) right bank with road crossing

Site 84

No waterway could be identified in area of the amber mapped feature, or within 250 m in either direction along the east to west track. A small drainage channel was identified approximately 500 m further to the west (see Unmapped Features section below).

Due to the lack of a waterway with any waterway features, Site 84 is not considered a waterway providing for fish passage (Figure 6.73).

a)

b)

c)

d)

Figure 6.73 Site 84 showing a) upstream, b) left bank with road crossing, c) downstream, and d) right bank with road crossing

Site 97 – Upstream End of Discernible Waterway

Site 97 contains discontinuous bed banks forming broken sections of a drainage feature (Figure 6.74). There are no riparian plants, with terrestrial grasses, weeds and shrubs throughout. The terrain is undulating, and described as a slight depression between the constructed quarry rock wall and flat farming land further to the west.

A search 100 m across from the quarry wall to the farming land to the west failed to find a defined waterway.

Due to the complete lack of any waterway features, Site 97 is not considered a waterway providing for fish passage.

Site 97 is the upstream limit of the waterway providing for fish passage along the northern mapped feature.

a)

b)

c)

d)

Figure 6.74 Site 97 showing a) upstream, b) left bank, c) downstream, and d) right bank

Site 96

Site 96 is a wide, shallow gully with low banks (Figure 6.75). The bed was cracked and dry in February 2022, but the nature of the cracked soils was indicative of previous water ponding. Further, aquatic plants (sedges (*Cyperus* spp.)) were abundant at this site, suggesting water may occur at Site 96 for an extended period following rainfall. These sedges and large woody debris provides fish habitat.

Site 96 is a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.75 Site 96 showing a) upstream, b) left bank, c) downstream, and d) right bank

Site 95

Site 95, immediately downstream of Site 96, is located at a road crossing (Figure 6.76). The road is approximately 0.4 m above the adjoining channel bed, creating a significant barrier to fish passage. Immediately upstream of Site 95, the channel is a depression with dry, cracked beds, indicating water is likely pooling up against the road. While not visible at the time of the assessment, it appears pooled water would eventually overtop the road and flow downstream to lower reaches.

a)

b)

c)

d)

e)

Figure 6.76 Site 95 showing a) upstream, b) left bank road crossing, c) downstream, d) right bank road crossing, and e) unconsolidated/cracks soils with a deceased crab located on upstream side of road

Site 94

Site 94 is a small, 12 m wide, shallow pool of water (Figure 6.77). The pool has low banks and connectivity to upstream and downstream reaches. The channel flowing into the pool is not well defined and appears to be directing overland flows from the dirt road described at

Site 95. The channel downstream of Site 94 is a rocky, moderately steep channel, which appears to have been constructed with rocks added to create some scour protection.

Aquatic plants (sedges) are growing in the pond and along the downstream channel. These plants, along with rocks and large woody debris, provide fish habitat.

At the time of the assessment kangaroos and water birds were present. Fish were also captured within the pond as part of the fish survey (see Section 3.2.2, Site QS1).

Site 94 is a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.77 Site 94 showing a) upstream side of pond, b) left bank of pond, c) downstream channel, and d) wider view of pond looking upstream

Site 93

Site 93 is a large, constructed dam (Figure 6.78). The dam has low banks, approximately 1 m in height above the water level in the dam. Vegetation surrounding the dam appears to be mostly terrestrial grasses with some aquatic plants, including bull rush (*Typha orientalis*) and knotweed *(Persicaria* sp.) growing within the shallow areas of the dam.

There is connectivity to upstream and downstream reaches during periods of flow. The upstream channel flowing into the dam contains bull rush and likely only conveys flows during periods of rainfall. The downstream connectivity is via the dam overflow, which is separated from the dam by a wide flat section of bare land used by cattle as a track. The overflow connects to a constructed channel (described below).

Fish were captured within the dam as part of the fish survey (see Section 3.2.2, Site Q1).

Site 93 is a waterway for fish passage during periods of flow to upstream reaches.

a)

b)

c)

d)

Figure 6.78 Site 93 showing a) upstream extent of dam , b) left bank of dam, c) downstream extent of dam, and d) looking downstream toward dam overflow

Site 91

Site 91 appears to have been constructed and lined with rocks to provide dam overflow passage to downstream reaches of the mapped feature (Figure 6.79).

The channel contains defined bed and banks, with aquatic plants (sedges) present. Fish were observed swimming in the channel but were not able to be captured due to the shallow rocky conditions.

Site 91 is a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.79 Site 91 showing a) upstream, b) left bank, c) downstream, and d) dam overflow

Site 90

Site 90 is a wide rocky constructed barrier located between Sites 93 and 89 (Figure 6.80). The barrier is approximately 2 m above the natural ground level and does not provide any fish habitat or fish passage opportunities. The constructed channel at Site 91 appears to have been created to allow flows around Site 90.

a)

b)

c)

d)

Figure 6.80 Site 90 showing a) across constructed barrier toward upstream dam, b) looking west, c) toward downstream, and d) looking east

Site 89

Site 89 is a small channel with defined bed and banks, immediately downstream of the constructed barrier at Site 90 (Figure 6.81). At the time of the assessment in February 2022, there was a small pool of green-coloured water. Aquatic plants (sedges) were present but sparse.

The pond likely receives overland flows from the constructed barrier and flat grazing land to the west. The pond appeared to be losing water and was estimated to be likely completely dry within a few days to a week. Connectivity to upstream reaches was blocked by the constructed barrier. Connectivity to downstream reaches would occur during periods of flow.

Fish were captured within the pond as part of the fish survey (see Section 3.2.2, Site QN1). However, due to the small pool drying out it was not thought that the fish within the pool would be able to persist. There was a complete lack of habitat opportunities within the pond.

Site 94 is a waterway providing for fish passage.

a)

b)

c)

d)

e)

Figure 6.81 Site 89 showing a) upstream of pond, b) left bank, c) looking downstream across pond, d) right bank, and e) looking downstream toward pond from constructed rock barrier

Site 88 (D5)

Site 88 (D5 in previous assessments; see Appendix A) is a waterway providing for fish passage. The channel contains defined bed and banks, with aquatic plants (sedges and rushes (*Juncus* sp.)) present (Figure 6.82). The nature of the cracked soils was indicative of previous water ponding.

Connectivity to upstream reaches would occur during periods of flow from the dam overflow.

a)

b)

c)

d)

e)

Figure 6.82 Site 88 (D5) showing a) upstream, b) left bank, c) downstream, d) right bank, and e) aquatic plants, with cracked soils

Site 87 (2 and 3)

Site 87 (Site 2 and Site 3 in previous assessments; see Appendix A) is immediately upstream of a rail bridge with a large box culvert. A dirt road also crosses the channel with a narrow (0.4 m diameter) pipe culvert passing under the road (Figure 6.83). There was a rabbit inhabiting the pipe culvert suggesting flows had not occurred within this reach of the

waterway for some time. The channel upstream of the dirt road was wide and flat, with low banks. While no aquatic plants were present, woody debris provided potential fish habitat. Downstream toward the box culvert, the channel was narrow and drops down to a depression around the box culvert. It is likely that water pools in this area after flows.

Site 87 is a waterway providing for fish passage.

a)

b)

c)

d)

e)

f)

Figure 6.83 Site 87 (2 and 3) showing a) upstream, b) left bank with road crossing, c) downstream toward rail box culvert, d) right bank with road crossing, e) looking downstream showing blocked pipe culvert under road, and f) downstream narrow channel toward rail culvert

Site 85

Site 85 is immediately downstream of the rail bridge with a large box culvert, described above. A dirt road crosses the channel (Figure 6.84). There is no culvert passing under the road. The channel downstream of the dirt road was wide and flat, with relatively low banks. Large *Eucalyptus* trees line the banks. Aquatic plants (sedge and rushes) were present.

The dirt road crossing may create a barrier to fish passage upstream, particularly during periods of low flow. However, during periods of high flow, when the upstream dam is overflowing, the water level likely overtops the road and allows fish passage to upstream reaches.

Site 85 is a waterway providing for fish passage.

a)

b)

c)

d)

e)

f)

Figure 6.84 Site 85 showing a) upstream toward rail box culvert, b) left bank with road crossing, c) downstream, d) right bank with road crossing, e) left bank downstream of road crossing, and f) downstream of road crossing

Site 98 (A12)

Site 98 (A12 in previous assessments; see Appendix B) is approximately 400 m upstream of the confluence with the Isaac River. A dirt road crosses the channel. The dirt road is at the same level as the channel bed, with no culvert passing under the road. Recent grading of the road has produced shallow banks of dirt across the channel creating possible barriers to fish passage (Figure 6.85).

The channel either side of the dirt road was wide and flat, with defined bed and banks. Large *Eucalypt* trees line the banks.

The grading from the dirt road may create a barrier to fish passage upstream, particularly during periods of low flow. However, during periods of high flow, when the upstream dam is overflowing, the water level would likely overtop the grading soil and allow fish passage to upstream reaches.

Site 98 is a waterway providing for fish passage.

a)

b)

c)

d)

e)

f)

Figure 6.85 Site 98 showing a) upstream, b) left bank with road crossing, c) downstream, d) right bank with road crossing, e) left bank downstream of road, and f) unconsolidated soils with indications of recent grading across channel bed

Central Unnamed Waterway

Sites 155 and 154

Sites 155 and 154 lack defined bed and banks and are indicative of overland flow paths that funnel immediate localised rainfall, and would not provide flow beyond the duration of a rain event (Figure 6.86 and Figure 6.87). Erosion is minimal suggesting flow velocities are low. Vegetation appears to be terrestrial grasses, with no aquatic plants. The soils are not indicative of previous water ponding.

This section of the mapped feature is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.86 Site 155 showing a) upstream, b) left bank, c) downstream, and d) right bank

a)

b)

c)

d)

e)

Figure 6.87 Site 154 showing a) upstream, b) left bank, c) downstream, d) right bank, and e) unconsolidated/cracks soils

Site 137

Site 137 is a narrow drainage gully directing flows toward a large, constructed dam and would not provide flow beyond the duration of a rain event (Figure 6.88). There is no riparian vegetation, aquatic plants or any other evidence of standing water.

The lack of defined bed and banks, in combination with insufficient water availability to sustain basic aquatic ecological processes and habitats, and the lack of riparian vegetation, suggests this reach of the mapped feature is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.88 Site 137 showing a) upstream, b) left bank, c) downstream, and d) right bank

Site 135 (FD1)

Site 135 (FD1 in previous assessments; see Appendix A) is a large, constructed dam (Figure 6.89). The dam walls are approximately 7 m high and act to restrict connectivity to downstream reaches. The dam wall along the downstream extent of the dam extends away from the dam to the south, which appears designed to direct dam overflows.

There is no riparian vegetation or shading, and a lack of habitat features. There appears to be no connectivity to downstream reaches.

The dam at Site 135 acts as a barrier to fish passage and there is no waterway providing for fish passage upstream (see Site 137 described above) or downstream (Figure 6.89e).

a)

b)

c)

d)

e)

Figure 6.89 Site 135 showing a) upstream across dam, b) left bank of dam, c) downstream, toward dam overflow, d) toward dam from dam overflow, and e) looking downstream from dam overflow

Sites 133 (6) and 134

Sites 133 (Site 6 in previous assessments; see Appendix A) and 134 are small drainage depressions, downstream of the large constructed dam, that lack features of a waterway providing for fish passage (Figure 6.90 and Figure 6.91).

There are several small drainage lines running through Site 133, converging downstream at Site 134. There is some erosion along the edges of the drainage lines, particularly on the outside of bends. Sections of the depressions do not have a continuous defined bed and banks, and instead consist of broken sections of a drainage gully, particularly along straight sections of the channel. The drainage depression at these sites would not likely provide adequate flow other than in times of localised rainfall.

Due to the lack of a channel with continuously defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Sites 133 and 134 are not waterways providing for fish passage.

a)

b)

c)

Figure 6.90 Site 133 showing a) upstream toward dam b) left bank, with multiple drainage lines, and c) downstream, away from dam

a) b)

Figure 6.91 Site 134 showing a) upstream toward dam with several drainage lines visible, and b) downstream

Site 138

Site 138 is a wide flat drainage gully, with no standing water or evidence of previous standing water (Figure 6.92). There is significant erosion along the edges of some of the gullies, particularly on the outside of bends.

Site 138 is unlikely to provide adequate flow beyond the duration of a rainfall event. There are no aquatic plants and a lack of fish habitat opportunities.

Due to the lack of a main channel with continuously defined bed and banks, no riparian vegetation, lack of fish habitat or passage opportunities, Site 138 is not considered a waterway providing for fish passage.

a)

b)

c)

d)

e)

f)

Figure 6.92 Site 138 showing a) upstream, b) left bank, c) downstream, d) right bank, e) unconsolidated/cracks soils, and f) vegetated gully floor

Site 139

Site 139 is a drainage feature/overland flow path. The area is mostly flat, with no continuously defined bed and banks; rather, there are broken sections of a drainage line (Figure 6.93).

Terrestrial vegetation grows across the feature and there is no indication of adequate flow beyond an immediate rainfall event. There are no fish habitat or fish passage opportunities at this site.

Due to the lack of a channel with continuously defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Site 139 is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.93 Site 139 showing a) upstream, b) left bank, c) downstream, and d) right bank

Site 140

Site 140 is a constructed dam (Figure 6.94). There was no water within the dam during the February 2022 site assessment. The dam walls are approximately 3 m in height and restrict connectivity to downstream reaches. The dam wall along the downstream extent of the dam extends away from the dam to the east, providing the dam overflow. The dam overflow is approximately 1.5 m above the base of the dam.

There is no clearly defined drainage channel flowing into the dam from upstream reaches, suggesting the dam collects overland flows. There is no riparian vegetation or shading, and a lack of habitat features. There appears to be no connectivity to downstream reaches.

The dam at Site 140 acts as a barrier to fish passage.

a)

b)

c)

d)

e)

Figure 6.94 Site 140 showing a) upstream toward dam, b) left bank of dam, c) downstream from dam, d) unconsolidated/cracks soils, and e) looking along dam wall toward dam overflow

Site 143

Site 143 is a wide flat drainage depression downstream of the dry constructed dam (Figure 6.95). There is erosion in places, particularly along outer bends.

Terrestrial vegetation is growing across the drainage depression. The drainage depression flattens out further downstream from the dam, forming of broken sections of a drainage gully.

The drainage depression at Site 143 would not provide adequate flow other than in times of localised rainfall.

Due to the lack of a channel with continuously defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, this site is not considered a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.95 Site 143 showing a) upstream toward dam, b) left bank, c) downstream, and d) right bank

Site 132 (5)

Site 132 (Site 5 in previous assessments; see Appendix A) is a flat overland flow area, with no defined bed and banks (Figure 6.96). A road cuts across the feature, with no culvert. Terrestrial vegetation can be seen growing across the feature.

Due to a lack of any evidence of a waterway channel, this reach of the mapped feature is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.96 Site 132 showing a) upstream, b) left bank with road crossing, c) downstream, and d) right bank with road crossing

Sites 73 and 72 (B2)

Sites 73 and 72 (B2 in previous assessments; see Appendix A) are wide flat drainage gullies, with no standing water in February 2022 (Figure 6.97 and Figure 6.98). There is significant erosion along the edges of some of the gullies, particularly on the outside of bends. There is a shallow vegetated depression within the gully with terrestrial vegetation, indicating that it is unlikely to provide adequate flow beyond the duration of a rainfall event. There are no aquatic plants or fish habitat.

Due to the lack of a main channel with continuously defined bed and banks, no riparian vegetation, lack of fish habitat or passage opportunities, Sites 73 and 72 are not considered a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.97 Site 73 showing a) upstream, b) left bank, c) downstream, and d) right bank

a)

b)

c)

d)

Figure 6.98 Site 72 (B2) showing a) upstream, b) left bank, c) downstream, and d) right bank

Site 102

Site 102 is a wide flat overland flow area, immediately upstream of a large, constructed dam (Figure 6.99).

There are no continuously defined bed and banks; instead, there are broken sections of a drainage depression in places, particularly along straight sections of the channel. The drainage depression at these sites would not likely provide adequate flow other than in times of localised rainfall.

Due to the lack of a channel with continuously defined bed and banks, no riparian vegetation, lack of fish habitat or passage opportunities, Site 102 is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.99 Site 102 showing a) upstream, b) left bank, c) downstream, and d) right bank

Site 101 (FD2)

Site 101 (FD2 in previous assessments; see Appendix A) is a constructed dam (Figure 6.100). The dam walls are approximately 8 m high and restrict connectivity to downstream reaches. There is no dam overflow on the downstream extent of the dam wall. There is a small drainage channel that funnels flow into the dam from upstream reaches (Site 102, discussed above). There is no shading and a lack of habitat features. There appears to be no connectivity to downstream reaches.

The dam at Site 101 acts as a barrier to fish passage.

a)

b)

c)

d)

Figure 6.100Site 101 showing a) downstream toward dam, b) looking downstream direction into dam entrance, c) looking upstream away from dam entrance, and d) looking upstream away from dam

Sites 71 and 70 (1)

Sites 71 and 70 (Site 1 in previous assessments; see Appendix A) are located upstream and downstream of a road that crosses the mapped feature. The road is elevated to approximately 0.4 m above the natural ground level, with a narrow (0.4 m diameter) pipe culvert under the road.

Sites 71 and 70 are drainage gullies, with ill-defined bed and banks, and instead, consist of broken sections of a drainage channel (Figure 6.101 and Figure 6.102).

There are no aquatic plants, no standing water, and no fish habitat opportunities.

This section of the mapped feature is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.101Site 71 showing a) upstream, b) left bank with road crossing, c) downstream, road pipe culvert, and d) right bank with road crossing

a) b)

c) d)

Figure 6.102Site 70 showing a) upstream, b) left bank, c) downstream, and d) right bank

Site 69

Site 69 is a drainage depression crossed by a dirt track, with no culvert passing under the track (Figure 6.103).

There appears to be some erosion along the edges of the depression, particularly on the outside of bends. However, straight sections of the depression do not have a continuous defined bed and banks, and instead consist of broken sections of a drainage gully. The drainage depression would only flow in times of localised rainfall.

Due to the lack of a channel with continuously defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Site 69 is not a waterway providing for fish passage.

a)

b)

c)

d)

e)

Figure 6.103Site 69 showing a) upstream, b) left bank, c) downstream, d) right bank and e) recent grading across channel

Site 129

Site 129 is a wide drainage gully, with no visible standing water in February 2022 (Figure 6.104). A small depression within the gully contained cracked soils that were indicative of some pooling of water after periods of flow. However, the depression appears to be a gully that funnels immediate localised rainfall that would not likely provide flow beyond the duration of a rain event. There was no evidence of aquatic flora or fauna (such as dead aquatic plants

or aquatic fauna) occurring within the depression. There is some erosion along the sides of the gully, particularly along the outside of bends. However, the eroded sides of the gully are likely from periods of high velocity flows and do not form continuously defined bed and banks. Vegetation growing within the gully consists of terrestrial grasses, with no aquatic plants.

This section of the waterway is not a waterway providing for fish passage.

a)

b)

c)

d)

e)

Figure 6.104Site 129 showing a) upstream, b) left bank, c) downstream, d) right bank, and e) dried, cracked bed in depression

Sites 127 and 128

The mapped feature at Sites 127 to 128 is a drainage depression, or gully, that lacks the features of a waterway providing for fish passage (Figure 6.105 and Figure 6.106).

There is significant erosion of the silty unconsolidated soils, particularly on the outside bends of the gully. However, this section of the gully does not have a continuously defined bed and banks, and in some sections consists of broken sections of a drainage gully, particularly along straight sections of the channel. The drainage depression along this section of the mapped feature would not likely provide adequate flow other than in times of localised rainfall.

Due to the lack of a channel with continuously defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Sites 127 and 128 are not considered waterways providing for fish passage.

a) b)

c) d)

Figure 6.105Site 127 showing a) upstream, b) left bank, c) downstream, and d) right bank

a)

b)

c)

d)

e)

Figure 6.106Site 128 showing a) upstream, b) left bank, c) downstream, d) right bank, and e) erosion on the outside of bank full width channel on bend

Site 126 through to Site 122 (inc. B5 and B6)

This long section of the mapped feature (includes B5 and B6 from previous assessments; see Appendix A) is described as broken sections of a drainage gully, consisting of a wide flat gully with shallow sloping sides (Figure 6.107 to Figure 6.115). In some sections, the gully splits into several smaller gullies/drainage lines. There is some erosion present, particularly on the outside of bends.

This section of the mapped feature would be unlikely to provide adequate flow beyond the duration of a rainfall event. There is no aquatic vegetation present and no fish habitat opportunities; however, there was some evidence of previous water ponding, such as dead mussel shells, but the ponding appeared to be infrequent. This section of the waterway does not provide fish passage opportunities.

Due to the lack of a channel with continuously defined bed and banks, no riparian vegetation, lack of fish habitat or passage opportunities, this section of the mapped feature is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.107Site 126 showing a) upstream, b) left bank, c) downstream, and d) right bank

a)

b)

c)

d)

Figure 6.108Site 103 showing a) upstream, b) left bank, c) downstream, and d) right bank

a)

b)

c)

d)

Figure 6.109Site 125 showing a) upstream, b) left bank, c) downstream, including right bank, and d) dried cracked bed

a)

b)

c)

d)

Figure 6.110Site 68 showing a) upstream, b) left bank with track crossing, c) downstream, and d) right bank with track crossing

a)

b)

c)

d)

Figure 6.111Site 104 showing a) upstream, b) left bank, c) downstream, and d) right bank

a)

b)

c)

Figure 6.112 Site 123 showing a) upstream, b) downstream, and c) cracked soils with broken mussel shells

a)

b)

c)

d)

e)

Figure 6.113 Site 124 showing a) upstream, b) left bank, c) downstream, d) right bank, and e) unconsolidated soils

a)

b)

c)

d)

e)

Figure 6.114 Site 121 showing a) upstream, b) left bank, c) downstream, d) right bank, and e) unconsolidated/cracked soils in a depression

a)

b)

c)

d)

e)

Figure 6.115 Site 122 showing a) upstream, b) left bank, c) downstream, d) right bank, and e) mussel shell observed within a gully

Site 66

Site 66 is a drainage depression directing flows toward a large, constructed dam (Figure 6.116).

There are no continuously defined bed or banks, or any other waterway features. There is no evidence of areas of standing water and no aquatic vegetation. The drainage depression funnels flow toward the dam and would not provide flow beyond the duration of a rain event.

The lack of defined bed and banks, in combination with insufficient water availability to sustain basic aquatic ecological processes and habitats, suggests this reach of the mapped feature is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.116 Site 66 showing a) upstream, b) left bank, c) downstream toward dam, and d) right bank

Site 65 (FD3)

Site 65 (FD3 in previous assessments; see Appendix A) is a constructed dam (Figure 6.117). The dam walls are approximately 7 m high restrict connectivity to downstream reaches. The dam wall extends away from the dam to the south, which appears designed to direct overland flows into the dam. The dam overflow is in the northwest corner of the dam. There is a drainage channel that directs overland flows into the dam (Site 64). There is no riparian vegetation or shading, and a lack of habitat features. While fish have been captured in the dam (see site R13 in Section 3.2.1.2), there is no connectivity upstream or downstream of the dam

The dam at Site 65 acts as a barrier to fish passage.

a)

b)

c)

d)

Figure 6.117 Site 65 showing a) upstream toward dam, b) left bank of dam, c) dam wall extending away from dam to catch/direct overland flows, and d) toward dam overflows

Site 64

Site 64 is a drainage gully immediately downstream of the constructed dam (Figure 6.118). The drainage gully consists of broken sections of a drainage depression, with no continuous defined bed and banks, and no evidence of standing water.

Site 64 would be unlikely to provide adequate flow beyond the duration of a localised rainfall event. There are no aquatic plants, and a lack of fish habitat opportunities. There is no defined channel leading from Site 64 toward the dam overflow, suggesting this section of the waterway does not provide fish passage opportunities.

Due to the lack of a channel with defined bed and banks, no riparian vegetation, lack of fish habitat or passage opportunities, Site 64 is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.118 Site 64 showing a) upstream toward dam wall, b) left bank, c) downstream, and d) right bank

Site 63 (B7)

Site 63 (B7 in previous assessments; see Appendix A) consists of broken sections of a drainage channel passing through an undulating paddock (Figure 6.119). A dirt road passes across the drainage channel in a north-south direction.

The drainage channel does not consist of continuously defined bed and banks, there is no standing water present, and no aquatic vegetation. The depression is a channel that likely funnels immediate localised rainfall that would not provide flow beyond the duration of a rain event. Vegetation consists of terrestrial grasses.

There is no culvert passing under the road and no visible channel running across the road, indicating there have been no recent flows from upstream reaches.

Due to the lack of a channel with continuously defined bed and banks, no riparian or aquatic vegetation, a lack of fish habitat or passage opportunities, Site 63 is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.119 Site 63 (B7) showing a) upstream with road crossing, b) left bank, c) downstream, and d) right bank

Sites 62 – Upstream End of Discernible Waterway

Site 62 consists of multiple drainage lines (Figure 6.120).

There are no continuous defined bed or banks, or any other waterway features. There is no evidence of previous standing water. Broken sections of a drainage channels funnel immediate localised rainfall and would not likely provide flow beyond the duration of a rain event.

The lack of continuous defined bed and banks, in combination with insufficient water availability to sustain basic aquatic ecological processes and habitats, and the lack of aquatic vegetation, suggests this reach of the mapped feature is not a waterway providing for fish passage.

There are waterway features downstream of this point. As such, Site 62 is the upstream limit of the waterway providing for fish passage along the central mapped feature.

a)

b)

c)

d)

Figure 6.120 Site 62 showing a) upstream, b) left bank, c) downstream, and d) right bank

Sites 60 to 58

Sites 60 through to 58 are representative of a waterway providing for fish passage. The channel along this section of the mapped feature contains a defined bed and banks (Figure 6.121 to Figure 6.124). Large *Eucalypts* and other native trees line the sides of the banks. Multiple habitat opportunities, including woody debris and rocky structures, were observed throughout.

While no standing water was found in the channel, several depressions were identified that likely provided standing water during and after periods of flow.

a)

b)

c)

d)

e)

Figure 6.121 Site 60 showing a) upstream, b) left bank, c) downstream, d) right bank, and e) unconsolidated soils with sections of exposed rocky bed

a)

b)

Figure 6.122 Site 59 showing a) upstream, and b) downstream

a)

b)

c)

d)

Figure 6.123 Site 57 (B8) showing a) upstream, b) left bank with road, c) downstream, and d) right bank with road

a)

b)

c)

d)

Figure 6.124 Site 58 showing a) upstream, b) left bank, c) downstream, and d) right bank

Sites 120 and 119

Our assessment found Sites 120 and 119 are drainage depressions. There appears to be some erosion along the edges of some of the drainage depressions, particularly on the outside of bends (Figure 6.125). However, there was no continuous defined bed and banks; rather, there were broken sections of a drainage depression, particularly along straighter sections. The drainage depression at these sites would not likely provide adequate flow other than in times of localised rainfall.

Due to the lack of a channel with continuously defined bed and banks, no aquatic plants, and a lack of fish habitat and connectivity for fish passage, Sites 120 and 119 are not waterways providing for fish passage.

a)

b)

c)

d)

e)

f)

Figure 6.125 Site 120 showing a) upstream, b) left bank, c) downstream, and d) right bank; and Site 119 showing e) upstream, and f) downstream

Site 56 (U7)

Site 56 (U7 in previous assessments; see Appendix A) is a drainage depression that lacks the features of a waterway providing for fish passage (Figure 6.126). A slightly raised dirt road crosses the drainage depression, with no culvert passing under the road.

There appears to be some minor erosion along the edges of some of the depression, particularly on the outside of bends. However, straighter sections of the depression do not have a continuously defined bed and banks. The drainage depression would not provide adequate flow other than in times of localised rainfall. Due to the lack of a channel with continuously defined bed and banks, no aquatic plants, and a lack of fish habitat and connectivity for fish passage, Site 56 is not a waterway providing for fish passage.

a)

b)

c)

d)

e)

f)

Figure 6.126 Site 56 showing a) upstream, b) left bank with road crossing, c) downstream, d) right bank with road crossing, e) looking upstream from approximately 100m downstream, unconsolidated soils, and f) further downstream

Southern Unnamed Waterway

Site 111

Site 111 is a drainage depression directing overland flows along a diversion wall toward a large, constructed dam (Figure 6.127). There are no continuously defined bed or banks, or any other waterway features. There is no evidence of standing water or of flow beyond the duration of a rain event.

The lack of defined bed and banks, in combination with insufficient water availability to sustain basic aquatic ecological processes and habitats, and the lack of aquatic vegetation, means this reach of the mapped feature is not a waterway providing for fish passage.

a)

b)

c)

d)

e)

f)

Figure 6.127 Site 111 showing a) upstream along diversion wall, b) left bank with road crossing, c) downstream toward dam, d) right bank with road crossing, e) diversion wall, and f) additional view of downstream flow toward dam

Site 112 (FD4)

Site 112 (FD4 in previous assessments; see Appendix A) is a constructed dam (Figure 6.128). The dam walls are approximately 7 m in height and restrict connectivity to downstream reaches. There is a drainage channel on the western extent of the dam that funnels flow into the dam from upstream areas. Aquatic plants within the dam include bull rush, rushes, and sedges.

The dam at Site 112 acts as a barrier to fish passage.

Outside of the dam, a narrow drainage gully runs along the northern edge of the dam wall, and likely directs dam overflow downstream, to the east. This drainage gully consists of broken sections of a drainage channel and does not have continuous defined bed and banks, or any other waterway features. The drainage channel is not a waterway providing for fish passage.

a)

b)

c)

d)

e)

f)

Figure 6.128 Site 122 showing a) upstream of dam with flow entrance and overflow, b) looking downstream across dam, c) overflow channel from dam looking upstream, d) overflow channel looking downstream e) overflow channel further downstream, and f) channel spreading out into paddock as drainage line

Site 116

Site 166 is immediately downstream, to the east of the constructed dam (Figure 6.129). It is a narrow drainage depression that lacks features of a waterway providing for fish passage.

The drainage depression consists of broken sections of a drainage gully, particularly along straight sections of the channel, and does not have a continuously defined bed and banks. The drainage depression at Site 116 would not flow other than in times of localised rainfall.

Due to the lack of a channel with continuously defined bed and banks, no aquatic vegetation, and a lack of fish habitat and connectivity for fish passage, Site 116 is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.129 Site 116 showing a) upstream, b) left bank, c) downstream, d) right bank, and e) unconsolidated soils

Site 117

Site 117 is a slight depression or pool, adjacent to the constructed dam (Figure 6.130). The depression likely collects overland flows during localised rain events. The depression would be approximately 30 cm deep when completely full.

The are no aquatic plants and the bed of the depression is covered in terrestrial grasses. A slight depression allows flows from the pool to the east. It is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.130 Site 117 showing a) upstream from depression toward dam, b) left bank, c) downstream, and d) right bank

Sites 99 (C4) and 100 (C5)

Sites 99 and 100 (C4 and C5 in previous assessments; see Appendix A) consist of an overland flow area (Figure 6.131 and Figure 6.132). There are multiple drainage depressions directing flows from across the wide flat terrain, with no discernible main channel.

The drainage depressions at Sites 99 and 100 would be unlikely to provide adequate flow beyond the duration of a rainfall event. There is a complete lack of fish habitat and fish passage opportunities.

Due to the lack of a channel with defined bed and banks, no aquatic vegetation, lack of fish habitat or passage opportunities, Sites 99 and 100 are not waterways providing for fish passage.

a)

b)

c)

d)

Figure 6.131 Site 99 showing a) upstream, b) left bank, c) downstream, and d) right bank

a)

b)

c)

d)

Figure 6.132 Site 100 showing a) upstream, b) left bank, c) downstream, and d) right bank

Site 144 (LW5)

Site 144 (LW5 in previous assessments; see Appendix A) is a large, constructed dam on the neighbouring Olive Downs property (Figure 6.133). The dam walls are approximately 10 m in height and restrict connectivity to downstream reaches. Significant earthworks have occurred on the southern side of the dam to direct additional flows toward the dam.

There is a dam overflow on the northern side of the dam, which connects to a wide gully that is eroding into the side of a hill on the outside of a wide sloping bend. Within the gully there is a depression containing bullrush and sedges.

There is a drainage gully that funnels flow into the dam from upstream reaches. The drainage gully is wide and shallow and appears to consist of broken sections of a drainage channel. The bed of the gully was composed of terrestrial grasses and weeds with no aquatic plans visible.

The dam at Site 144 acts as a barrier to fish passage.

a)

b)

c)

d)

e)

f)

g)

h)

Figure 6.133 Site 144 showing a) upstream across dam, b) left bank along dam wall, c) downstream, looking upstream toward dam overflow , d) looking downstream away from dam overflow, e) unconsolidated/cracks soils within dam, f) looking upstream of dam, g) upstream view of drainage gully flowing toward dam, and f) downstream view of gully with dam wall in background

Site 151 (C10)

Site 151 (close to C10 from previous assessments; see Appendix A) is located at a road crossing a drainage depression (Figure 6.134). The road is approximately 0.4 m above the drainage depression. Immediately upstream of Site 151, there are dry, cracked beds, indicating water is likely pooling up against the road. The depression consists of broken sections of a drainage channel and does not have continuously defined bed and banks.

Downstream of the road, there is a shallow wide overland flow area. There is no visible bed and banks. Brigalow (*Acacia harpophylla*) grow throughout the overland flow area, indicating a lack of sustained flow through this section of the mapped feature.

The lack of defined bed and banks, in combination with insufficient water availability to sustain basic aquatic ecological processes and habitats, and the lack of aquatic vegetation, suggests this reach of the mapped feature is not a waterway providing for fish passage.

However, as sites downstream of this location were not surveyed, and as there was an indication of water pooling on the upstream site of the road crossing, Site 151 has conservatively been considered the upstream extent of the waterway providing for fish passage for the southern unnamed feature.

a)

b)

c)

d)

e)

f)

Figure 6.134 Site 151 showing a) upstream, b) left bank, c) downstream, with road crossing, d) downstream from road crossing, e) unconsolidated/cracked soils, and f) showing lack of defined drainage channel further downstream within brigalow

Unmapped features

Site 82 (D4)

Site 82 (D4 in previous assessments; see Appendix A) is an overland flow area lacking the features of a waterway providing for fish passage (Figure 6.135). The area is flat, with no defined bed and banks and terrestrial vegetation. There are no fish habitat or fish passage opportunities at this site, or within a 200 m diameter search of the area surrounding Site 82.

Due to the lack of a channel with defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Site 82 is not considered a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.135 Site 82 (D4) showing a) upstream, b) left bank, c) downstream, and d) right bank

Site 83

Site 83 consists of broken sections of a drainage depression, with no evidence of past standing water or fish habitat (Figure 6.136). The drainage depression consists of broken sections of a drainage channel and does not have defined bed and banks. Site 83 would be unlikely to provide adequate flow beyond the duration of a rainfall event.

Due to the lack of a channel with defined bed and banks, no aquatic vegetation, lack of fish habitat or passage opportunities, Site 83 is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.136 Site 83 showing a) upstream, b) left bank, c) downstream, and d) right bank

Site 108

Site 108 is a drainage depression, or gully, directing flows toward a large, constructed 'turkey's nest' dam (Figure 6.137).

There are no continuously defined bed or banks, or any other waterway features. Terrestrial grasses are growing throughout the gully and there was no aquatic vegetation. There is no evidence of past standing water. The drainage depression funnels flow toward the dam and would not provide flow beyond the duration of a localised rain event.

The lack of defined bed and banks, in combination with insufficient water availability to sustain basic aquatic ecological processes and habitats, suggests this reach of the unmapped feature is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.137 Site 108 showing a) upstream, b) left bank, c) downstream, and d) right bank

Site 105 (FD5)

Site 105 (FD5 in previous assessments; see Appendix A) is a constructed 'turkey's nest' dam (Figure 6.138). The dam walls are approximately 6 m in height and restrict connectivity to downstream reaches.

There is a drainage channel that funnels flow into the dam from upstream reaches (Site 108, discussed above). There is a drainage depression leading from the dam flow entrance along the northern boundary of the dam, where it slowly sweeps around, and away, to the south. The drainage depression does not have continuously defined bed and banks. There are bullrushes and sedges growing within the edges of the dam.

The dam at Site 105 acts as a barrier to fish passage.

a)

b)

c)

d)

e)

f)

g)

Figure 6.138 Site 105 showing a) upstream across dam, b) left bank of dam, c) downstream from dam, d) right bank, e) downstream from dam wall, f) drainage channel leading away from dam, and g) dam flow entrance and overflow

Site 109

Site 109 is south of the large, constructed dam at Site 107. Here, the ground is undulating with no clear drainage channel (Figure 6.139). Instead, the site consists of several drainage depressions leading in a southerly direction. The area is reminiscent of undulating Gilgai country.

Due to the lack of a channel with continuously defined bed and banks, no riparian vegetation, and a lack of fish habitat and connectivity for fish passage, Site 109 is not a waterway providing for fish passage.

a)

b)

c)

d)

Figure 6.139 Site 109 showing a) upstream, b) left bank, c) downstream, and d) right bank

Site 110

Site 110 is a wide flat, slight depression approximately 0.75 km south of the large, constructed dam at Site 107. It appears overland flows during periods of high rainfall flow from the north and fill this depression to create a large, shallow wetland.

There were no aquatic plants at the time of the assessment, and the large depression does not have defined bed or banks (Figure 6.140). During periods of high rainfall, it is possible that this site provides ponded water and aquatic habitat. However, it is unlikely to provide fish passage opportunities as there does not appear to be any connectivity to waterways upstream or downstream of the site.

a)

b)

c)

d)

e)

f)

Figure 6.140 Site 110 showing large depression, looking a) south, b) west, c) north, and d) east, with road