



Miralga

**Groundwater Dependent Vegetation
Assessment**

Atlas Iron Pty Ltd

December 2019



Introduction and Background

Atlas Iron Pty Ltd (Atlas Iron) are currently exploring the feasibility of the Miralga Project and require the use and reactivation of several existing groundwater bores, ALB0006, ALB0009, ALB0066, ALB0067, ALB0010, ALB0008, ALB0038, ALB0039 and ALB0041, to continue proposed on-ground works at Miralga (Figure 1). Prior to abstracting groundwater, Atlas Iron have requested an assessment of Groundwater Dependent Vegetation within a stretch of Shaw River, Six Mile Creek, Sulphur Springs Creek and an unnamed creek, totalling approximately 30 kilometres (km) of riparian vegetation.

The purpose of the assessment is to determine the true extent of GDVs, provide fine-scale mapping of GDV units and search for phreatophytic flora species that may be adversely impacted by groundwater abstraction. The key species for this assessment is *Melaleuca argentea* which is known to access groundwater at or close to the surface.




Objective and Scope of Work


The overarching objective of the Project was to refine the GDV mapping to fine-scale map the functional vegetation units in the identified areas (Figure 1). This objective was met via the following:

- A desktop assessment to further understand vegetation unit VT05 and the key phreatophytic species previously documented as occurring within the vegetation unit.
- A site visit to map the functional units along the Study Area. We investigated VT05 within the drawdown contour of 0.5 m and a further 1 km north and south along Shaw River and Sulphur Springs Creek. The only exceptions to this were:
 - The area that contains bore ALB0008. VT05 was not previously mapped in this area (within the 0.5m contour), therefore we investigated the drainage to the west and confirmed VT05 to the east; and
 - The Study Area that contains bores ALB0038, ALB0039, and ALB0041. We investigated north of where the mapping for VT05 ends (there was no reason to investigate 1 km out of the drawdown to the north). We investigated 1 km south of the 0.5m contour; and
 - The area to the west of bores ALB006, ALB009, ALB010, ALB066 and ALB067 within Six Mile Creek. VT05 was not previously mapped in this area, therefore we investigated this area to confirm the presence of phreatophytic flora.
- Prepare a letter style report (this report) detailing the results of the fine-scale mapping and map the location of any susceptible phreatophytic flora (i.e. *Melaleuca argentea*) that may be impacted by the proposed groundwater abstraction.




Legend

-  Study Area
-  Drawdown Countours
-  Bore




biologic
Environmental Survey

N



1:140,000

0 1.5 3 6 km



Atlas Iron Limited
GDV Assessment
Fig. 1: Study Area and Proposed Bore Locations

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 15/12/2019

Methods

The scope of works included a desktop assessment, field survey and the preparation of a letter style report (this report) and raw data submission.

Desktop Assessment

A desktop assessment was completed prior to, during, and at the completion of, the field survey to identify the key phreatophytic flora species that are known to occur, or have the potential to occur, within vegetation unit VT05. The desktop assessment included a review of relevant reports, database, literature and online portals. The online databases and publicly available datasets reviewed included:

- Atlas of Living Australia (ALA, 2019) Occurrence Search;
- Department of Biodiversity, Conservation and Attractions (DBCA) NatureMap online portal (DBCA, 2019);
- Determining water level ranges of Pilbara riparian species (Loomes, 2010);
- The riparian flora and plant communities of the Pilbara region of Western Australia (Lyons, 2015); and
- Assessment of groundwater dependent vegetation distribution on the Robe River (Rio Tinto, 2018).

The report, vegetation mapping and dataset for the Miralga flora and vegetation assessment completed by Woodman Environmental Consulting (WEC) was not available prior to the completion of the field survey. The mapping of VT05 was provided prior to the field survey.

Field Survey

A three-day site field survey was completed from the 3rd to the 5th of December 2019 by Clinton van den Bergh (Principal Botanist) and Emily Eakin-Busher (Botanist). The field survey involved traversing the Study Area to fine-scale map the functional units within vegetation unit VT05, which had been identified as potentially supporting groundwater dependent vegetation. Additional areas within the 0.5 m drawdown contour that coincided with minor creeks and drainage lines were also traversed as they were considered as potential habitat for phreatophytic species. The field survey included:

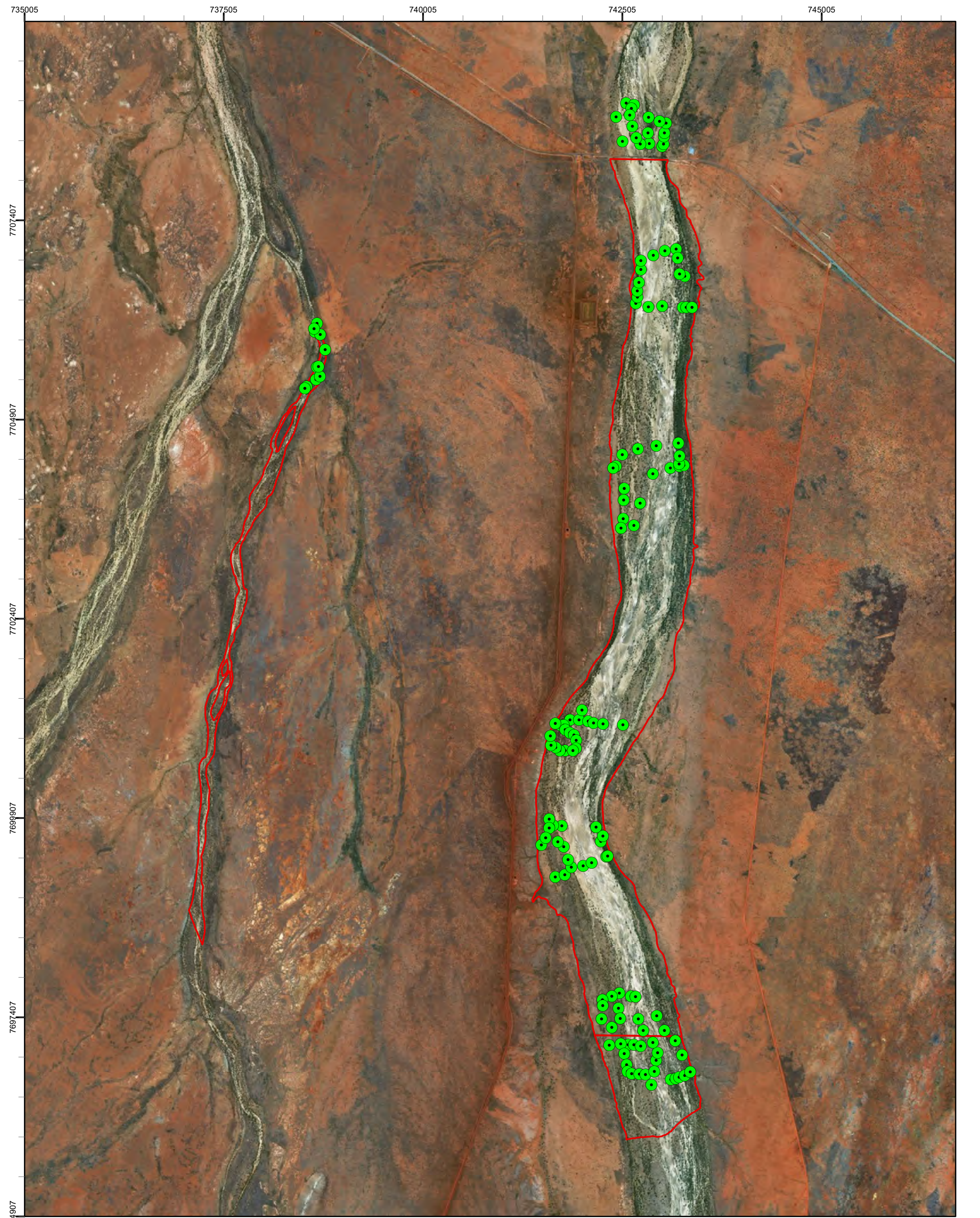
- 16 km section of Shaw River split across two sections (bores ALB0006, ALB0009, ALB0066, ALB0067, ALB0010 and ALB0008);
- A 8 km section of Six Mile Creek (bore ALB0006, ALB0009, ALB0066, ALB0067 and ALB0010);
- A 5.5 km section of Sulphur Springs Creek (bores ALB0038, ALB0039, ALB0041); and
- A 1 km section of an unnamed creek near bore ALB0008 (Figure 1).

A total of 189 sites were assessed (Figure 2) to refine VT05. At each site broad information was collected to assist in the mapping of the functional units, including a description of the vegetation, the presence or absence of *Melaleuca argentea* and the presence of any additional phreatophytic flora species, with particular emphasis on species that require groundwater to be at or just below the surface (obligate phreatophytes, for example *Sesbania formosa*).



The functional units that were mapped within the Study Area included: *Melaleuca argentea* dominated areas, *Eucalyptus camaldulensis* dominated areas; *Eucalyptus victrix* dominated areas; *Acacia* dominated areas; *Corymbia* dominated areas; floodplains variously dominated by shrubs/ trees; and bare river/ creek beds.

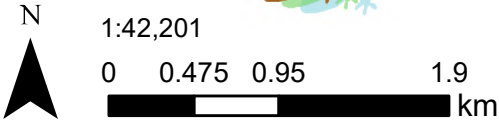
Due to the extent of the Study Area and the limited accessibility via formal tracks, site traverses were restricted to easily accessible areas and pre-identified areas of vegetation that may support obligate phreatophytic flora. For example, the aerial imagery was interrogated to identify areas of dense canopy cover along Shaw River, which was hypothesised that these areas may contain mature *Melaleuca argentea* and potentially permanent or semi-permanent pools.

The field survey was undertaken during very hot daytime conditions with maximum's ranging between 42.6°C to 44.9°C at the Marble Bar weather station (station number 4106; BoM, 2019). As a result of the high daytime temperatures, site traverses were limited to easily accessible areas. Traverses from the vehicle were limited to a maximum of 2 km straight line distances from the vehicle for health and safety reasons. Due to the hot temperatures and restrictions in walking distance from the vehicle a portion of Six Mile Creek (approximately 6.5 km) was not traversed as the nearest access tracks were beyond 2 km from the creek. A 1.5 km section of Six Mile Creek was traversed, with access obtained near the northern extent of the area of the creek requiring a field survey.



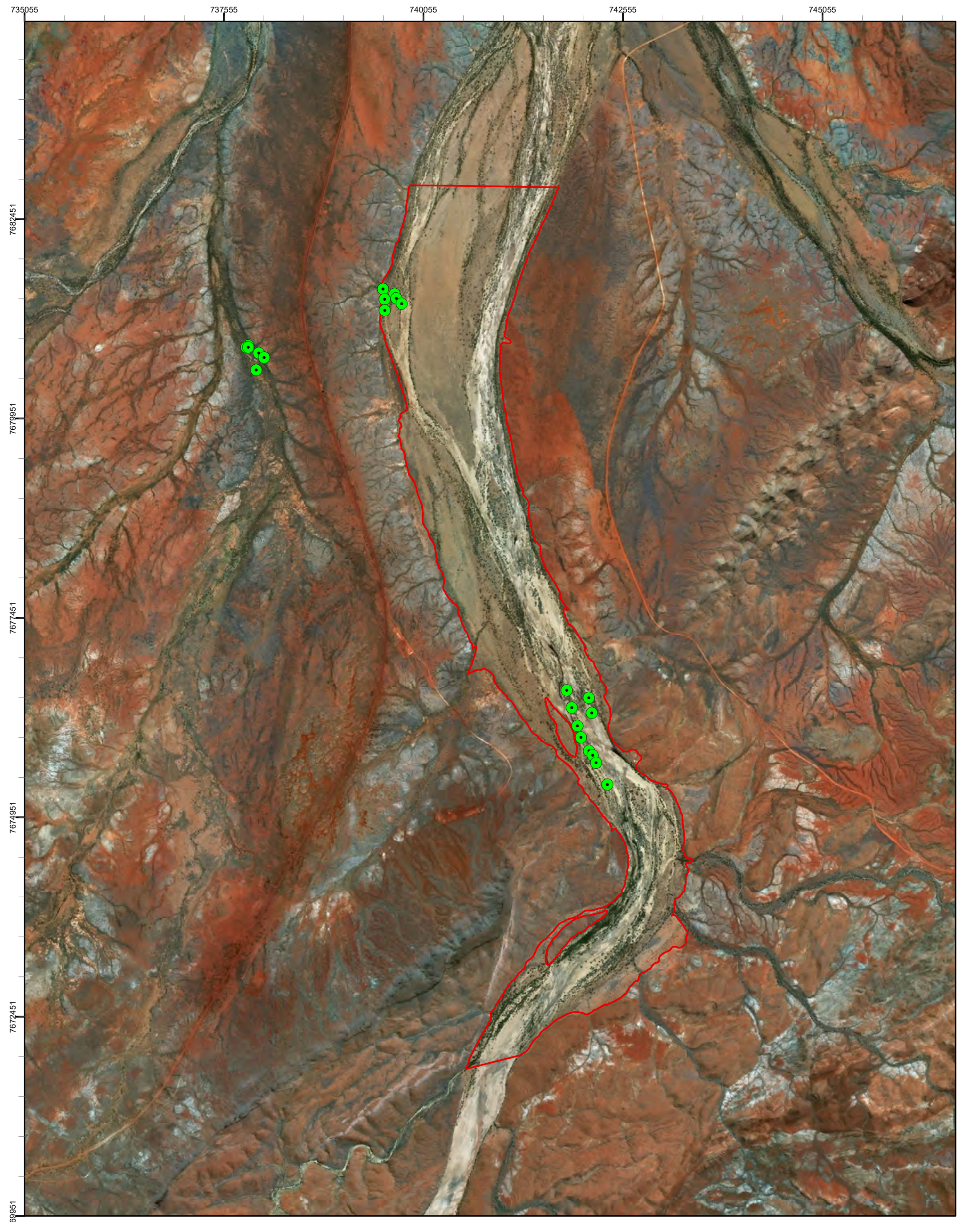
Legend

-  Study Area
-  Sample Sites





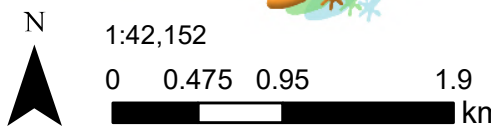
Atlas Iron Limited
GDV Assessment
Fig. 2a: Mapping Note Locations

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A3. Created 15/12/2019



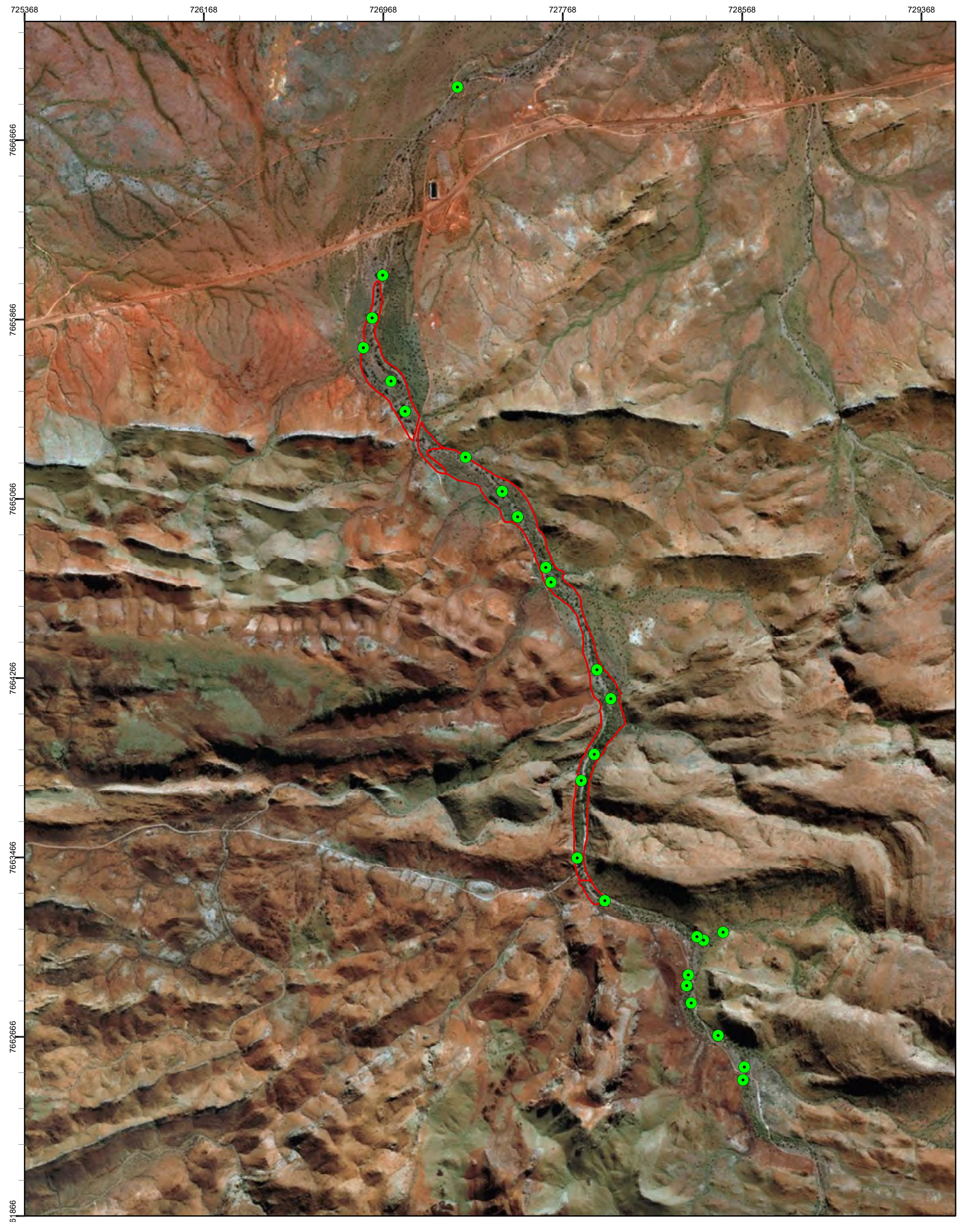
Legend



-  Study Area
-  Sample Sites




Atlas Iron Limited
GDV Assessment
Fig. 2b: Mapping Note Locations

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A3. Created 15/12/2019




- Legend**
-  Study Area
 -  Sample Sites




biologic
Environmental Survey

N



1:15,000

0 0.15 0.3 0.6 km



Atlas Iron Limited
GDV Assessment
Fig. 2c: Mapping Note Locations

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 15/12/2019

Results

Riparian Vegetation Units





WEC has mapped the vegetation within the Study Area as VT05, which is broadly described as a *Melaleuca argentea* and *Eucalyptus camaldulensis* mid open forest to open woodland. The field survey delineated seven broad functional units across the Study Area, ranging from *Acacia* dominated shrublands (139.21 ha), bare river/ creek bed (116 ha), *Corymbia* dominated woodland (2.72 ha), *Eucalyptus camaldulensis* dominated woodlands (482.59 ha), *Eucalyptus victrix* dominated woodlands (88.59 ha), floodplains (0.10 ha) and *Melaleuca argentea* dominated woodlands (582.62 ha). Although these functional units were only mapped within the Study Area, they are known to extend further upstream and downstream along Shaw River, Sulphur Springs Creek, Six Mile Creek and regionally based on aerial interpretation and work completed by Biologic at Mt Webber (Biologic, 2019). The seven broad functional units were further separated into 14 riparian vegetation units (Table 1 and Figure 3).





The obligate phreatophyte *Melaleuca argentea* was recorded from all survey areas, excluding the unnamed creek located near bore ALB0008. The dominant riparian vegetation units mapped in the Study Area were the *Melaleuca argentea* units (MA1, MA2, MA3 and MA4; Table 1), with these units occurring across the length and width of the Shaw River. Additional phreatophytic species identified from the study Area included, but not limited to: *Sesbania formosa*, *Eucalyptus camaldulensis*, *Cullen leucanthum*, *Melaleuca linophylla*, *Melaleuca glomerata*, *Acacia ampliceps*, *Atalaya hemiglauca*, *Acacia coriacea* subsp. *pendens*, *Cyperus vaginatus* and *Typha domingensis* (Rio Tinto, 2018). The relative importance of each species in relation to access to groundwater varies, with *Melaleuca argentea* and *Sesbania formosa* considered to be the key phreatophytic species observed across the Study Area.





The *Melaleuca argentea* dominated woodlands occurred throughout Shaw River with isolated occurrences along Six Mile Creek and Sulphur Springs Creek. It was the dominant functional unit (582.62 ha mapped) and was further delineated into four separate riparian vegetation units. The four riparian vegetation units were separated based on the density and dominance of *Melaleuca argentea*:



- **MA1:** *Melaleuca argentea* with occasional *Eucalyptus camaldulensis* and *Sesbania formosa* mid to low open forest over *Cyperus vaginatus* low to mid scattered sedges;
- **MA2:** *Melaleuca argentea* with occasional *Eucalyptus camaldulensis* mid to low open woodland over *Acacia trachycarpa*, *Atalaya hemiglauca* and **Calotropis procera* tall to mid sparse to scattered shrubs over *Cyperus vaginatus* mid scattered sedges;
- **MA3:** *Melaleuca argentea* low scattered trees over *Acacia trachycarpa*, *Melaleuca glomerata* and occasional **Calotropis procera* mid to tall sparse shrubland over scattered shrubs and sedges; and
- **MA4:** *Melaleuca argentea* low scattered trees over isolated patches of *Cyperus vaginatus* and *Cyperus xiocarpus* over isolated herbs and tussock grasses.

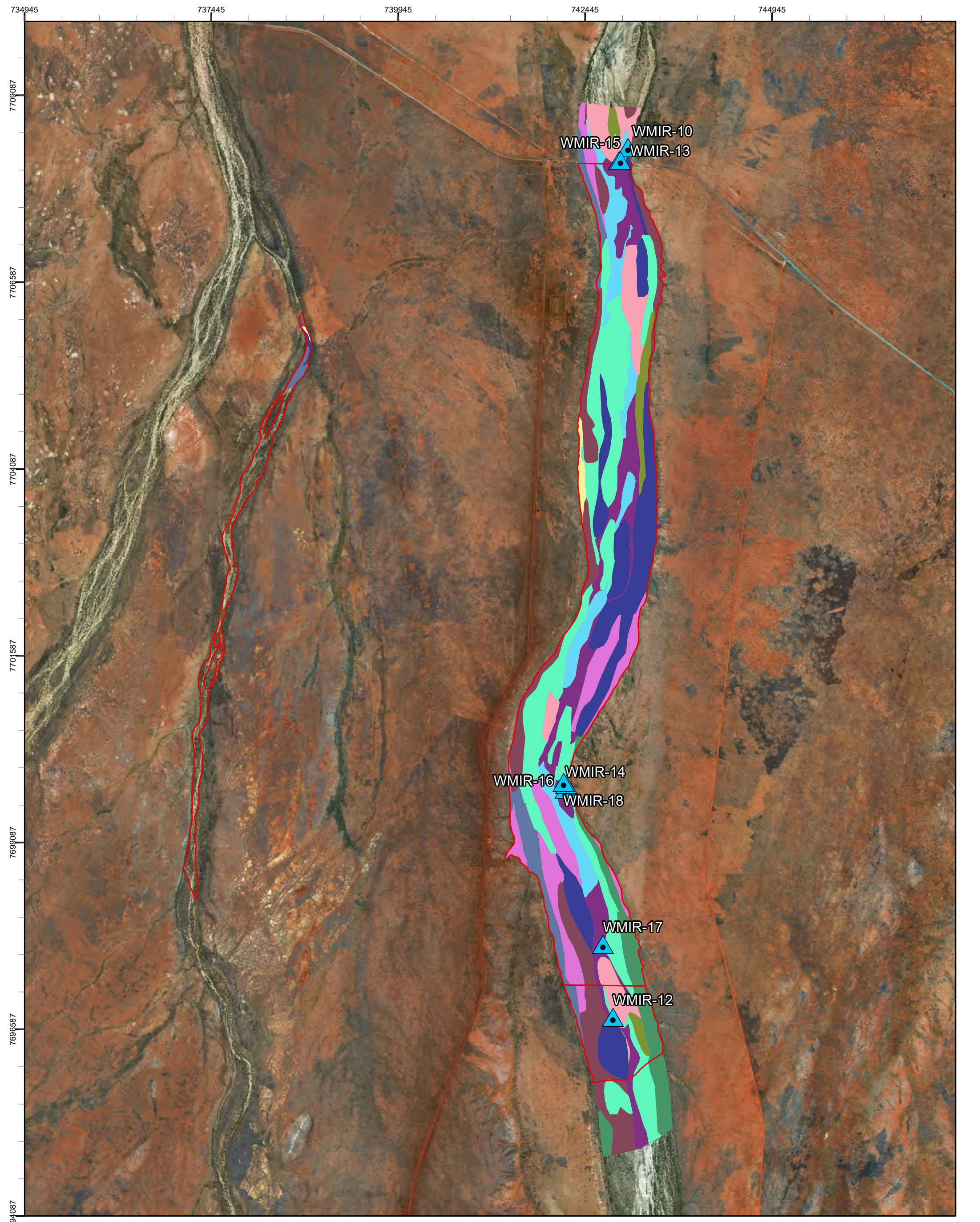
Table 1: Broad Functional Units and Riparian Vegetation Units mapped from the Study Area

Map Code	Broad Functional Unit	Vegetation Unit	Extent (ha)	Photo
AM	Acacia dominated Shrubland	<i>Acacia coriacea</i> subsp. <i>pendens</i> , <i>Melaleuca glomerata</i> and <i>Melaleuca linophylla</i> tall shrubland over <i>Triodia epactia</i> low sparse hummock grassland	4.17	
AT	Acacia dominated Shrubland	<i>Acacia trachycarpa</i> , <i>Atalaya hemiglauca</i> and occasional * <i>Calotropis procera</i> mid to tall shrubland over * <i>Cenchrus ciliaris</i> scattered low tussock grasses	135.04	
B	Bare River/ Creek Bed	Bare river/ Creek bed with isolated shrubs, herbs and sedges	116.00	
CH	Corymbia dominated Woodland	<i>Corymbia hamersleyana</i> low scattered trees over <i>Acacia pyrifolia</i> and <i>Acacia trachycarpa</i> tall to mid scattered shrubs over * <i>Cenchrus ciliaris</i> scattered tussock grasses	2.72	














Map Code	Broad Functional Unit	Vegetation Unit	Extent (ha)	Photo
EC1	<i>Eucalyptus camaldulensis</i> dominated Woodland	<i>Eucalyptus camaldulensis</i> and occasional <i>Melaleuca argentea</i> mid to low open woodland over <i>Atalaya hemiglauc</i> , <i>Acacia trachycarpa</i> and * <i>Calotropis procera</i> tall to mid scattered to open shrubland over * <i>Cenchrus ciliaris</i> low scattered tussock grasses	209.86	
EC2	<i>Eucalyptus camaldulensis</i> dominated Woodland (co-dominated with <i>Eucalyptus victrix</i>)	<i>Eucalyptus camaldulensis</i> and <i>Eucalyptus victrix</i> mid to low open woodland over <i>Atalaya hemiglauc</i> , <i>Acacia trachycarpa</i> and <i>Melaleuca glomerata</i> with occasional * <i>Calotropis procera</i> tall to mid sparse shrubland over low scattered tussock grasses	95.55	
EC3	<i>Eucalyptus camaldulensis</i> dominated Woodland	<i>Eucalyptus camaldulensis</i> mid to low open woodland over <i>Acacia trachycarpa</i> , <i>Melaleuca glomerata</i> and * <i>Calotropis procera</i> mid to tall sparse shrubland over * <i>Cenchrus ciliaris</i> low scattered tussock grasses	177.18	
EV1	<i>Eucalyptus victrix</i> dominated woodland (co-dominated with <i>Eucalyptus camaldulensis</i>)	<i>Eucalyptus victrix</i> with occasional <i>Eucalyptus camaldulensis</i> mid to low open woodland over <i>Acacia trachycarpa</i> , <i>Melaleuca glomerata</i> and <i>Acacia coriacea</i> subsp. <i>pendens</i> tall to mid scattered shrubs over scattered tussock or hummock grasses	12.33	


Map Code	Broad Functional Unit	Vegetation Unit	Extent (ha)	Photo
EV2	<i>Eucalyptus victrix</i> dominated woodland	<i>Eucalyptus victrix</i> mid to low scattered trees over <i>Melaleuca glomerata</i> , <i>Acacia trachycarpa</i> and <i>Atalaya hemiglauc</i> a tall sparse shrubland over scattered hummock and tussock grasses	76.26	
FP	Floodplain	Floodplain dominated by * <i>Cenchrus ciliaris</i>	0.10	
MA1	<i>Melaleuca argentea</i> dominated Woodland	<i>Melaleuca argentea</i> with occasional <i>Eucalyptus camaldulensis</i> and <i>Sesbania formosa</i> mid to low open forest over <i>Cyperus vaginatus</i> low to mid scattered sedges	33.52	
MA2	<i>Melaleuca argentea</i> dominated Woodland	<i>Melaleuca argentea</i> with occasional <i>Eucalyptus camaldulensis</i> mid to low open woodland over <i>Acacia trachycarpa</i> , <i>Atalaya hemiglauc</i> a and * <i>Calotropis procera</i> tall to mid sparse to scattered shrubs over <i>Cyperus vaginatus</i> mid scattered sedges	304.60	

Map Code	Broad Functional Unit	Vegetation Unit	Extent (ha)	Photo
MA3	Melaleuca argentea dominated Woodland	Melaleuca argentea low scattered trees over Acacia trachycarpa, Melaleuca glomerata and occasional *Calotropis procera mid to tall sparse shrubland over scattered shrubs and sedges	92.76	
MA4	Melaleuca argentea dominated Woodland	Melaleuca argentea low scattered trees over isolated patches of Cyperus vaginatus and Cyperus ixiocarpus over isolated herbs and tussock grasses	151.74	



Legend

	Study Area		AT		EC2		MA1
	Water Feature		BE		EC3		MA2
VegCode			CH		EV1		MA3
	AM		EC1		EV2		MA4



N

1:45,000

0 0.5 1 2 km

Atlas Iron Limited

GDV Assessment

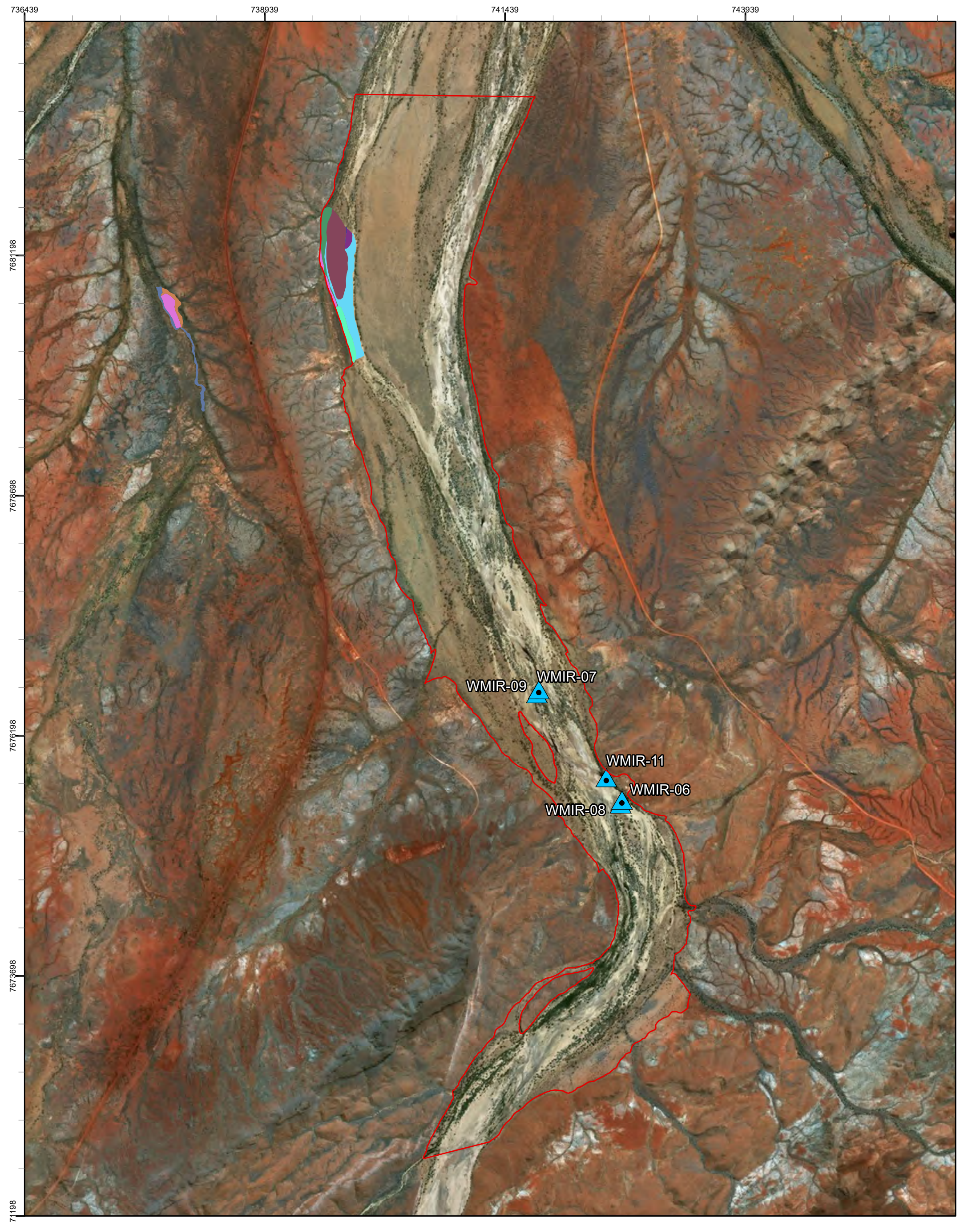
Fig. 3a: Vegetation and Pools

Coordinate System: GDA 1994 MGA Zone 50














Projection: Transverse Mercator

Datum: GDA 1994

Size A3. Created 15/12/2019



Legend

	Study Area		AT		EC2		MA1
	Water Feature		BE		EC3		MA2
VegCode			CH		EV1		MA3
	AM		EC1		EV2		MA4

biologic
Environmental Survey

N

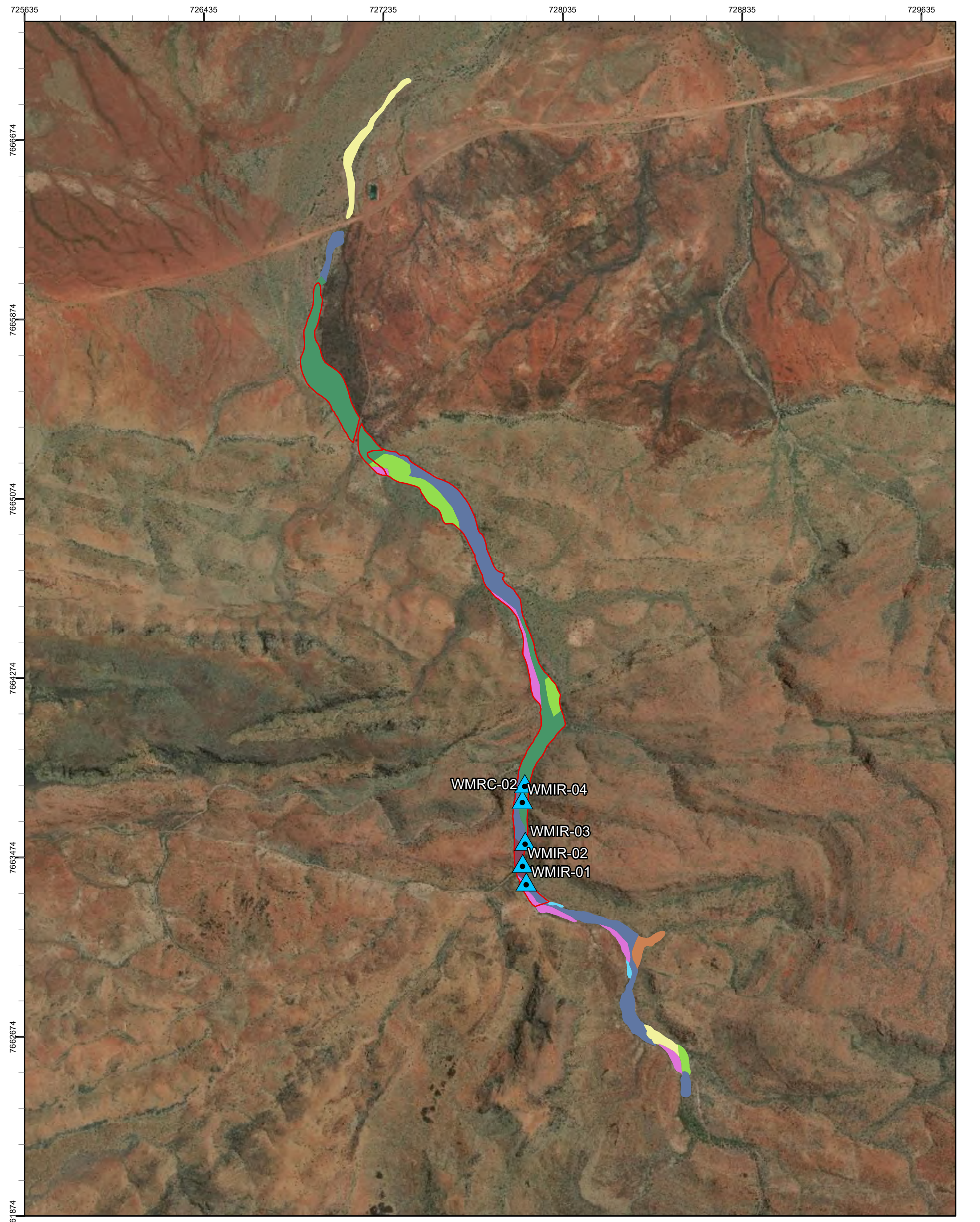
1:35,000

0 0.375 0.75 1.5 km









Atlas Iron Limited
GDV Assessment
Fig. 3b: Vegetation and Pools


Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 15/12/2019



Legend


	Study Area		AT		EC2		MA1
	Water Feature		BE		EC3		MA2
VegCode			CH		EV1		MA3
	AM		EC1		EV2		MA4



1:15,000

0 0.15 0.3 0.6 km

N



Atlas Iron Limited

GDV Assessment

Fig. 3c: Vegetation and Pools

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

Size A3. Created 15/12/2019

Additional phreatophytic species recorded from the *Melaleuca argentea* dominated woodlands included *Sesbania formosa*, *Eucalyptus camaldulensis*, *Acacia ampliceps*, *Cullen leucanthum*, *Melaleuca linophylla*, *Melaleuca glomerata*, *Atalaya hemiglauc*a and *Cyperus vaginatus*.

The *Eucalyptus camaldulensis* dominated woodlands mostly occurred along the margins of the *Melaleuca argentea* dominated woodlands within and along the banks of Shaw River, Six Mile Creek and Sulphur Springs Creek. This functional unit was the second most dominant unit and supported mature stands of *Eucalyptus camaldulensis*, sometimes co-dominated by *Melaleuca argentea* (EC1) and *Eucalyptus victrix* (EC2). The *Eucalyptus camaldulensis* dominated woodlands was separated into three riparian vegetation units:

- **EC1:** *Eucalyptus camaldulensis* and occasional *Melaleuca argentea* mid to low open woodland over *Atalaya hemiglauc*a, *Acacia trachycarpa* and **Calotropis procera* tall to mid scattered to open shrubland over **Cenchrus ciliaris* low scattered tussock grasses
- **EC2:** *Eucalyptus camaldulensis* and *Eucalyptus victrix* mid to low open woodland over *Atalaya hemiglauc*a, *Acacia trachycarpa* and *Melaleuca glomerata* with occasional **Calotropis procera* tall to mid sparse shrubland over low scattered tussock grasses
- **EC3:** *Eucalyptus camaldulensis* mid to low open woodland over *Acacia trachycarpa*, *Melaleuca glomerata* and **Calotropis procera* mid to tall sparse shrubland over **Cenchrus ciliaris* low scattered tussock grasses

Additional phreatophytic species recorded from this functional unit included *Melaleuca argentea*, *Atalaya hemiglauc*a, *Eucalyptus victrix*, *Melaleuca glomerata*, *Acacia coriacea* subsp. *pendens* and *Cyperus vaginatus*.

The *Eucalyptus victrix* dominated woodlands mostly occurred along the 'drier' edges of the Study Area, including the banks, side channels and minor creeks. The functional unit was recorded from Six Mile Creek, Shaw River, Sulphur Springs Creek and the unnamed creek. This functional unit was separated into two riparian vegetation units based on the presence of the co-dominant *Eucalyptus camaldulensis* (EV1):

- **EV1:** *Eucalyptus victrix* with occasional *Eucalyptus camaldulensis* mid to low open woodland over *Acacia trachycarpa*, *Melaleuca glomerata* and *Acacia coriacea* subsp. *pendens* tall to mid scattered shrubs over scattered tussock or hummock grasses
- **EV2:** *Eucalyptus victrix* mid to low scattered trees over *Melaleuca glomerata*, *Acacia trachycarpa* and *Atalaya hemiglauc*a tall sparse shrubland over scattered hummock and tussock grasses

Additional phreatophytic species present within this functional unit occurred across both the *Eucalyptus* dominated woodlands and included *Acacia coriacea* subsp. *pendens*, *Atalaya hemiglauc*a, *Acacia ampliceps*, *Cyperus vaginatus*, *Melaleuca linophylla* and *Melaleuca glomerata*.

The *Acacia* dominated shrublands occurred along the banks, floodplains and raised islands within Shaw River, Sulphur Springs Creek, Six Mile Creek and the unnamed creek. Generally,

they occurred where the local topography was higher than the river/ creek beds allowing greater separation between the groundwater and the natural surface. The *Acacia* dominated shrublands was separated into two riparian vegetation units based on the dominant *Acacia* species:

- **AM:** *Acacia coriacea* subsp. *pendens*, *Melaleuca glomerata* and *Melaleuca linophylla* tall shrubland over *Triodia epactia* low sparse hummock grassland
- **AT:** *Acacia trachycarpa*, *Atalaya hemiglauc* and occasional **Calotropis procera* mid to tall shrubland over **Cenchrus ciliaris* scattered low tussock grasses

The remaining three riparian vegetation units occurred across the Study Area with the riparian vegetation unit 'B' mostly confined to Shaw River. The Floodplain riparian vegetation unit occurred along a small section of Sulphur Springs Creek. The *Corymbia hamersleyana* dominated woodlands mostly occurred along Sulphur Springs Creek and the unnamed creek. This riparian vegetation unit occurred in areas that are drier with a larger separation between the groundwater and the natural surface. The three riparian vegetation units are described as:

- **B:** Bare river bed with isolated shrubs, herbs and sedges
- **FP:** Floodplain dominated by **Cenchrus ciliaris*
- **CH:** *Corymbia hamersleyana* low scattered trees over *Acacia pyrifolia* and *Acacia trachycarpa* tall to mid scattered shrubs over **Cenchrus ciliaris* scattered tussock grasses

Water Features

In addition to identifying the location of *Melaleuca argentea* and other terrestrial groundwater dependent ecosystems (GDEs), eighteen permanent and semi-permanent pools were identified from the mapped area (Figure 3 and Appendix A). The permanent and semi-permanent pools (Plate 1 and Plate 2) may support aquatic or other terrestrial GDE's (such as submerged macrophytes and aquatic fauna).

The water features identified from the Study Area mostly consisted of river bed pools which are potentially groundwater fed, and represent a location where the groundwater rises creating a surface expression. This surface expression may be permanent or may be a result of substantial rainfall received in the area during March 2019. Further studies would be required to determine the permanency of these water features.

Phreatophytic flora species were recorded at the majority of the water features, with *Melaleuca argentea* and *Eucalyptus camaldulensis* the prominent species observed. Other phreatophytic species were also recorded (i.e. *Cyperus vaginatus*, *Acacia ampliceps*, *Melaleuca linophylla*), while many of the water features were heavily impacted by cattle with algae presence and turbidity high.



Plate 1: Permanent or semi-permanent pool (WMIR-02) located along Sulphur Springs Creek



Plate 2: Large permanent or semi-permanent pool (WMIR-17)

Discussion

Substantial stands and individuals of *Melaleuca argentea* were recorded from within the 0.5 m drawdown contour, with individuals and vegetation units dominated by *Melaleuca argentea* located within 500 m of the proposed bores. In addition to the '*Melaleuca argentea* dominated

woodland' functional unit, 18 permanent and semi-permanent pools were located within the 0.5 m drawdown contour.

Drawdown in exceedance of 0.5 m associated with groundwater abstraction is likely to have some impact on phreatophytic vegetation within the riparian zone of the Study Area at the Miralga Project Area. Of the dominant riparian tree species in major creeks and rivers of the Pilbara, obligate phreatophytes such as *Melaleuca argentea* require continuous access to groundwater. *Eucalyptus camaldulensis* subsp. *obtusa* is a facultative phreatophyte and can either access groundwater or water from the capillary fringe meaning it can tolerate some degree of groundwater drawdown depending on the rate of fall and ability of roots to continue to access the capillary fringe. *Eucalyptus victrix* on the other hand is considered a facultative phreatophyte or a vadophyte (accessing moisture from throughout the soil profile) and is usually tolerant of drawdown. The response of individual trees is variable however and often depends on the conditions of their establishment.





Flora species *Sesbania formosa*, *Acacia ampliceps* and *Cullen Leucanthum*, recorded from the Study Area, are known to occur where soil moisture availability and consistency is high (Rio Tinto, 2018) and can be supplementary indicator species to support the presence of groundwater dependent vegetation. Although, the tolerance to groundwater drawdown has not been well documented, a study into water level changes of Pilbara riparian species indicated that the depth to groundwater for *Sesbania formosa* and *Acacia ampliceps* ranged from surface to approximately 3.5 m below the surface (Loomes, 2010). This range was relatively consistent with *Melaleuca argentea* (Loomes, 2010).





Any potential impact at Miralga from groundwater abstraction from bores ALB0006, ALB0009, ALB0066, ALB0067, ALB0010, ALB0008, ALB0038, ALB0039 and ALB0041 needs to be considered in the context of the current depth to groundwater, predicted drawdown (stated as 0.5 m), the rate of drawdown, the extent of time the drawdown will occur and likely surface (rainfall/ cyclonic) inputs which may mitigate these impacts. Potential impacts to *Melaleuca argentea* (and other obligate phreatophytes) may include canopy decline, deaths of younger recruits which have established following significant rainfall events and some losses of mature trees. Impacts may also occur to flora and fauna found in permanent pools.





References





- ALA, Atlas of Living Australia. (2019). Atlas of Living Australia; Occurrence search (custom search). Retrieved 2019 <http://www.ala.org.au/>
- Biologic, Environmental Survey. (2019). *Mt Webber Bore WEB0121 Groundwater Dependent Vegetation Assessment*. Unpublished report prepared for Atlas Iron Pty Ltd.
- BoM, Bureau of Meteorology. (2019). Climate Data Online. Retrieved 2019 <http://www.bom.gov.au/climate/data/index.shtml>
- DBCA, Department of Biodiversity, Conservation and Attractions. (2019). NatureMap: Mapping Western Australia's biodiversity (custom search). Retrieved 2019 <http://naturemap.dec.wa.gov.au/default.aspx>
- Loomes, R. (2010). *Determining water level ranges of Pilbara riparian species* (G. o. W. Australia Ed.). Perth, Western Australia: Government of Western Australia.
- Lyons, M. N. (2015). The riparian flora and plant communities of the Pilbara region of Western Australia. *Records of the West Australian Museum, Supplement*, 78(Part 2), 485-513.
- Rio Tinto, Rio Tinto Iron Ore. (2018). *Assessment of Groundwater Dependent Vegetation distribution on the Robe River - Targeted Riparian Vegetation Survey - Stage 1. High confidence mapping of the distribution of Obligate and Facultative Phreatophytic Vegetation between Mesa A and East Deepdale deposits on the Robe River*. Unpublished report prepared for Rio Tinto Iron Ore.



Appendix A: Waterbody Features

Waterbody Feature	Latitude	Longitude	Date Observed	Distance to Bore	Permanency ¹	Length (m)	Width (m)	Depth (m)	Vegetation	Fauna/ Other Comments	Photos
WMIR-01	-21.1167	119.1939	3/12/2019		Semi-permanent	4	1.8	0.9	A small pool along Sulphur Springs Creek (4m by 1.8m to a depth of 0.8m) with <i>Eucalyptus camaldulensis</i> present		
WMIR-02	-21.1160	119.1937	3/12/2019		Semi-permanent	25	1.5	0.7	A large pool, 25m by 1.5m to a depth of 0.7m with <i>Acacia ampliceps</i> , <i>Cyperus vaginatus</i> , <i>Eucalyptus camaldulensis</i> and <i>Melaleuca glomerata</i> present		
WMIR-03	-21.1151	119.1938	3/12/2019		Semi-permanent	20	3	0.5	A long thin pool (20m by 3m) supporting <i>Melaleuca glomerata</i> along Sulphur Springs Creek	Some damselflies and water beetles	
WMIR-04	-21.1134	119.1937	3/12/2019		Semi-permanent	60	1.5	0.4	A series of small pools along Sulphur Springs Creek with <i>Eucalyptus camaldulensis</i> present. Pools extend for 60m along access track	A series of small pools and puddles along track in creek bed	

Waterbody Feature	Latitude	Longitude	Date Observed	Distance to Bore	Permanency ¹	Length (m)	Width (m)	Depth (m)	Vegetation	Fauna/ Other Comments	Photos
WMRC-02	-21.1127	119.1938	3/12/2019		Non-permanent	1	1	0.3	Small pool supporting <i>Melaleuca argentea</i> and <i>Melaleuca linophylla</i>	Inverts present	
WMIR-06	-21.0054	119.3343	3/12/2019		Semi-permanent	40	16	1	A very large pool (40m by 16m) to a depth of 1m supporting <i>Melaleuca argentea</i> . High cattle activity	Lots of birds and cattle	
WMIR-07	-20.9951	119.3258	3/12/2019		Semi-permanent	12	2.5	0.4	River pool 12m by 2.5m to a depth of 0.4m with <i>Melaleuca argentea</i> present. Potential groundwater fed and permanent.	Small river pool. Groundwater fed?	
WMIR-08	-21.0050	119.3344	3/12/2019		Semi-permanent	20	4	0.8	A large pool (20m by 4m) supporting <i>Melaleuca argentea</i>		

Waterbody Feature	Latitude	Longitude	Date Observed	Distance to Bore	Permanency ¹	Length (m)	Width (m)	Depth (m)	Vegetation	Fauna/ Other Comments	Photos
WMIR-09	-20.9947	119.3259	3/12/2019		Non-permanent	2	1	0.3	Small eutrophied pool (2m by 1m) with <i>Melaleuca argentea</i> present	Lots of algae	
WMIR-10	-20.7083	119.3333	4/12/2019		Semi-permanent	10	4	0.5	A large pool (10m by 4m) supporting groundwater dependent vegetation (<i>Eucalyptus camaldulensis</i> and <i>Melaleuca argentea</i>)	Cows and birds	
WMIR-11	-21.0029	119.3328	3/12/2019		Non-permanent	2	1	0.2	Two small pools that are approximately 2m by 1m to a depth 0.2m and supporting <i>Melaleuca argentea</i>	Two small pools	
WMIR-12	-20.8134	119.3330	5/12/2019		Non-permanent	3	1	0.3	A small river puddle that is non-permanent	Small river pool. Non-permanent	

Waterbody Feature	Latitude	Longitude	Date Observed	Distance to Bore	Permanency ¹	Length (m)	Width (m)	Depth (m)	Vegetation	Fauna/ Other Comments	Photos
WMIR-13	-20.7098	119.3322	4/12/2019		Semi-permanent	5	2.5	0.5	A moderate semi-permanent pool 5m by 2.5m to a depth of 0.5m supporting <i>Melaleuca argentea</i> , <i>Eucalyptus camaldulensis</i> and <i>Cyperus vaginatus</i>		
WMIR-14	-20.7859	119.3265	5/12/2019		Non-permanent	1	1	0.3	A small river puddle that is non-permanent	River puddle	
WMIR-15	-20.7098	119.3324	4/12/2019		Semi-permanent	12	4	0.6	A large pool (12m by 4m) to a depth of 0.6m, supporting groundwater dependent vegetation (<i>Eucalyptus camaldulensis</i> and <i>Melaleuca argentea</i>)	Birds, damselflies, small fish	
WMIR-16	-20.7853	119.3266	5/12/2019		Semi-permanent	10	3	0.5	10m by 3m to a depth of 0.5m supporting <i>Eucalyptus camaldulensis</i> and <i>Melaleuca argentea</i>	Eutrophied river puddle with lots of cattle activity	

Waterbody Feature	Latitude	Longitude	Date Observed	Distance to Bore	Permanency ¹	Length (m)	Width (m)	Depth (m)	Vegetation	Fauna/ Other Comments	Photos
WMIR-17	-20.8046	119.3316	5/12/2019		Semi-permanent	20	6	0.6	A 20m by 6m pool with water depth to 0.6m supporting groundwater dependent vegetation (<i>Melaleuca argentea</i>)	Galah, Cockatiel, water bugs, fish and cattle	
WMIR-18	-20.7851	119.3262	5/12/2019		Semi-permanent	5	2	1	5m by 2m to a depth of 1m supporting <i>Melaleuca argentea</i>		

1 – the permanency of the waterbodies has been determined based on the size of the water body, the depth of the waterbodies, the presence of groundwater dependent vegetation/ flora, the presence of bedrock providing a barrier to infiltration and the presence of submerged macrophytes. The time of year the survey was undertaken also indicates some level of permanency, however this has also been reviewed in relation to the amount of rainfall the area may have received and the time of year the rainfall was recorded. The last substantial rainfall was recorded in March 2019 (246.2 mm) for the Marble Bar Weather Station (Station 004106; BoM, 2019)