



PEER REVIEW REPORT

Proposed Regional Resource Recovery Park

Broome, Western Australia

Submitted to:

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1.0 INTRODUCTION

1.1 Purpose and Terms of Reference

This Peer Review Report presents the findings from a peer review of selected site investigation and site comparison reports prepared for the proposed Broome Regional Resource Recovery Park (RRRP), to be located near Broome, Western Australia.

Golder Associates Pty Ltd (Golder) was commissioned by Shire of Broome (the Shire) on 24 December 2020 to undertake the peer review in accordance with Golder's email proposal, dated 17 December 2020.

1.2 Project Background

The Shire's current active landfill, the Broome Waste Management Facility, is approaching the end of its operational life. The Shire has undertaken a number of site selection studies over the last ten years to assess options for a new long-term resource recovery and waste disposal facility to meet the needs of the Broome community. The outcome of these studies was the selection by the Shire of two preferred sites for the proposed facility:

- **Site D2:** An approximately 119 ha site on Cape Leveque Road, approximately 12 km north-east of the Broome town centre. The site is currently undeveloped.
- **Site G1:** An approximately 98 ha site on Great Northern Highway, approximately 42 km from the Broome town centre. The site is currently undeveloped.

The proposed new facility is currently referred to as the Broome RRRP. Two possible development options are being considered by the Shire for delivery of the RRRP:

- **Development Option 1:** Develop all components of the RRRP, including a Class III landfill and community recycling centre, at Site D2.
- **Development Option 2:** Develop the RRRP over the two sites, namely:
 - Community recycling centre and waste transfer station at Site D2.
 - Class III landfill at Site G1.

In November 2019, the Shire commissioned more detailed site investigation and site comparison studies to further assess the feasibility of developing the Broome RRRP on one or both of the preferred sites. The Shire commissioned Golder to undertake a peer review of selected documents prepared during these studies.

1.3 Scope of Review

Golder's scope was to undertake a high-level peer review of the selected site investigation and site comparison documents prepared for the proposed Broome RRRP (refer to Section 2.0 for document list). The peer review covered the following subject areas:

- Landfill Engineering
- Hydrogeology
- Hydrology
- Geotechnical Engineering
- Flora and Fauna
- Heritage.

Other components of the studies, such as visioning, master planning, financial review and assessment, and social assessment were not included in the peer review.

Minor grammatical and typographical errors have been ignored for the purpose of this high-level review.

2.0 REVIEW DOCUMENTS

A list of documents provided to Golder for peer review is contained in Table 1. The table includes a shortened ‘document reference’ for each document, which has been used in this Peer Review Report for conciseness.

Table 1: List of Documents

Title	Shortened Document Reference	Author	Revision
Site Comparison Report, Broome Regional Resource Recovery Park	SCR	Talis Consultants	Version 1.2 (Draft) 3 Dec 2020
Site Investigation Report, Broome Regional Resource Recovery Park – Site D2	SIR-D2	Talis Consultants	Version 1a (Draft) 18 Jan 2021
Site Investigation Report, Broome Regional Resource Recovery Park – Site G1	SIR-G1	Talis Consultants	Version 1a (Draft) 27 Jan 2021
Broome Regional Resource Recovery Park Site Selection, Hydrology Assessment	HA	Talis Consultants	0b (Draft) 25 Nov 2020
Proposed Landfill Broome Cape Leveque Rd (Lot 25716) – Groundwater Source Protection Assessment	GSPA	Water Corporation	-*
Broome Regional Resource Recovery Facility, Reconnaissance Flora & Level 1 Fauna Survey	RFFS	Spectrum Ecology	Version 2 29 Jan 2020
Broome Regional Resource Recovery Park, Detailed Flora & Vegetation Assessment	DFVA	Spectrum Ecology	Version 2 3 July 2020
Broome Regional Resource Recovery Park, Terrestrial Fauna Assessment	TFA	Spectrum Ecology	Version 2 23 July 2020
Broome Shire Regional Resource Recovery Park, Heritage Survey Report	HSR	Kimberley Land Council	20 March 2020

Note: *No date or revision number is provided on this document

3.0 REVIEW FINDINGS

3.1 Landfill Engineering

3.1.1 Reviewer

The landfill engineering review was undertaken by Liza du Preez, Principal Landfill Engineer at Golder. Liza has around 24 years' experience as a landfill designer and has carried out landfill designs at various landfill sites in Western Australia, Victoria, Queensland, and South Africa.

3.1.2 Summary of Information Presented

The SCR has been prepared to compare Development Option 1 and Development Option 2. Development Option 1 is proposed to be located at site D2 and will consist of a Class III landfill and community recycling centre (CRC). Development Option 2 will comprise a landfill at site G1 and the CRC at site D2.

The SCR contains the proposed conceptual layout details for the CRC components as well as conceptual details and plans for the landfill.

Site investigation reports [SIR-D2 and SIR-G1] have been prepared for each of the two sites and cover, hydrogeology, geology, hydrology, fauna and flora, and heritage aspects.

3.1.3 Review Comments and Recommendations

The SCR, SIR-D2, and SIR-G1 reports are generally deemed appropriate for the level of investigation required at this stage of the project. Review comments and recommendations are presented in Table 2.

Table 2: Review Comments – Landfill Engineering

No.	Comment	Recommended Approach
1	<u>SCR, Section 3.2</u> Cognisance should be taken that the majority of liquid wastes contain hydrocarbons. All the hydrocarbons are unlikely to be removed prior to water being transferred to the evaporation pond, which is to be lined with HDPE. Hydrocarbons are known to be detrimental to the long-term performance of HDPE.	The SCR should acknowledge this potential constraint. Further assessment should be undertaken during detailed design phase.
2	<u>SCR, Section 3.3, Bullet 3</u> The figure after the description of the capping includes a gas collection and bedding layer, as well as a drainage layer above the geosynthetic capping material.	The SCR description of the capping system should be amended to match the figure.
3	<u>SCR, Section 4.2</u> The site description includes the maximum and minimum site elevations.	The SCR description of the topography should be amended to include the general slope of the site.
4	<u>SIR-D2 and SIR-G1</u> No assessment has been included on the in-situ soils available on the site for use in landfill construction.	The SIR-D2 and SIR-G1 should include a preliminary assessment on the suitability of the site soils to be utilised as: <ul style="list-style-type: none"> ■ Foundation material for the landfill ■ Attenuation layer below the geosynthetic liner system ■ Capping materials ■ Landfill perimeter bund construction We expect further assessment of these aspects will be undertaken during detailed design phase.

3.2 Hydrogeology

3.2.1 Reviewer

The hydrogeology review was undertaken by Alan Puhalovich, Principal Hydrogeologist at Golder. Alan has around 28 years' experience as a hydrogeologist and has undertaken hydrogeological assessments at various landfill sites in Western Australia and New South Wales.

3.2.2 Summary of Information Presented

Site hydrogeological investigations have been undertaken at both sites D2 and G1 [SIR-D2 and SIR-G1]. At each site, these investigations comprised the drilling of shallow and deep groundwater (monitoring) wells and a production well, aquifer testing, a single groundwater monitoring "event" (measurement of groundwater levels) and groundwater sampling for water quality analyses.

Using the above collected data, conceptual site models were developed at each site, and fate and transport and risk assessments (to human health and the environment) completed.

Other studies have been undertaken to support the assessment of potential impacts to important downstream receptors:

- A hydrology assessment was completed for the two sites [HA].
- A comparison study was undertaken, assessing the relative risks of the two sites to groundwater systems [SCR].
- An existing, calibrated groundwater model was utilised to assess whether potential seepage at the D2 landfill site could be captured by pumping by the public water supply borefield located to the east of D2 [GSPA].

3.2.3 Review Comments and Recommendations

Generally, the site investigative approaches and hydrogeological model/risk assessment methodologies adopted at both sites are appropriate. Key comments and recommendations arising from the hydrogeology review are presented in Table 3.

Table 3: Review Comments – Hydrogeology

No.	Comment	Recommended Approach
1	<u>GSPA</u> The Water Corporation has utilised a calibrated model to assess likely pathways of landfill seepage-affected groundwater. The modelling approach appears to be sound but the assumptions around bore pumping at Water Corporation bores and other bores have not been described.	The GSPA should confirm the bore pumping assumptions (sites and rates) used in the model and that this reflects Water Corporation's future pumping plans. The model should consider the results of field investigations at the D2 site and pumping from the proposed production well at D2. The GSPA should clearly show the extents of the Water Corporation bore capture zones.
2	<u>SIR-D2 Section 8 & SIR-G1 Section 8:</u> The SIR-D2 and SIR-G1 estimate transmissivity (T) of 1,300 and 194 m ³ /m/day based on the results of water level responses from bores that partially-penetrates the aquifer. Hydraulic conductivity (K) was then estimated to be 9 and 1.3 m/day (respectively) by dividing T by the full aquifer thicknesses. In both cases, K values and seepage velocity estimates are likely to have been under-estimated.	The SIR-D2 & SIR-G1 should re-assess the derivation of hydraulic conductivity to reflect the part of the aquifer tested. This should be cross-checked with GSPA's assumptions.
3	<u>SIR-D2, Section 10:</u> The SIR-D2 uses the results of field investigations to support the modelling assessment. Once the site is cleared and the landfill is constructed, increasing local recharge rates and changing groundwater flow gradients in the wet season. Importantly, site water supplies are planned to be obtained from a site production well. Potential seepage from the landfill may be captured by this well rather than migrate offsite or be captured by adjacent Water Corporation bores.	The SIR-D2 should assume operation of the production well and re-assess whether potential seepage from the landfill could be collected within the capture zone of the production well.
4	<u>SIR-D2, Section 10:</u> The SIR-D2 uses the results of field investigations (including a single groundwater monitoring event) to support the modelling assessment. The seasonal fluctuations of groundwater conditions at the landfill site should be discussed in the context of potential changes groundwater flow gradients and velocities.	The SIR-D2 should discuss seasonal groundwater level fluctuations and whether flow gradients and potential downstream receptors change seasonally.
5	<u>SIR-D2, Section 10:</u> The SIR-D2 undertakes hydrogeological modelling to assess potential impacts to downstream water quality. Focus has been on ammonia, although other water quality parameters related to landfill seepage are likely to be at elevated concentrations.	The SIR-D2 should elaborate further on why focus has been on ammonia and consider assessing potential impacts related to other water quality parameters.
6	<u>SIR-D2, Section 3:</u> The SIR-D2 makes the statement...."Consistent with the views of Water Corporation, the Broome Town Bore Field is located up hydraulic gradient of the Site and therefore not considered a down hydraulic gradient receptor."	The SIR-D2 should describe the Water Corporation's modelling study and its approach (i.e. use of particle tracking approach to assess potential direction of seepage-affected groundwater) rather than statements such as "...with the views of Water Corporation".
7	<u>SIR-G1, Sections 10 & 11:</u> The SIR-G1 estimates seepage velocity to be 2 m/yr in Section 10 whereas it is estimated to be 21 m/yr in Section 11.	The seepage velocity estimate should be checked and re-assessed.
8	<u>SCR</u> The study concludes that the risk of potential seepage from the landfill to groundwater is higher at G1 than D2, given that groundwater levels are significantly shallower at the G1 site. Specifically, the average minimum depth to water at D2 is 24.15 m (15-31 m range), whereas the	This is an important outcome but is not captured in the individual site investigation reports. It would be helpful that the risk of seepage to groundwater is discussed in these (SIR-D2 & SIR-G1) reports.

No.	Comment	Recommended Approach
	average minimum depth to water at G1 is 6.12 m (3-9 m range).	

3.3 Hydrology

3.3.1 Reviewer

The hydrology review was undertaken by Amila Basnayaka, Senior Water Resources Engineer at Golder. Amila has around 13 years' experience as a civil and water resources engineer and has undertaken hydrological assessments at various landfill sites in Western Australia.

3.3.2 Summary of Information Presented

Site hydrological investigations have been undertaken at both sites D2 and G1, considering both the existing site conditions and proposed site conditions [HA]. These investigations included flood assessments, estimating flood levels at each site for annual exceedance probability (AEP) events of 1% and 0.2% (similar to 1 in 100 year and 1 in 500 year average recurrence interval (ARI) events, respectively).

The flood assessment was undertaken utilising HEC-RAS software to develop two-dimensional (2D) flood models. The runoff peak flows were also estimated utilising the Regional Flood Frequency Estimation (RFFE) method presented in Ball *et al.* 2019.

The rainfall intensity frequency duration (IFD) data for the site was developed based on the latest IFD data sourced from the Bureau of Meteorology and assuming highest point rainfall intensities occur across the entire catchment instead of using areal reduction factor (ARF). The adopted infiltration loss rates extracted from the Australian Rainfall and Runoff (ARR) data hub and the surface roughness losses appear to be in the acceptable range. Critical duration event analysis was undertaken considering various duration storm events and the resulting critical duration events were 3-hour and 24-hour for site D2 and site G1 respectively.

Based on the flood modelling results, both sites are likely to be flooded for both 1% and 0.2% AEP events. Levees and stormwater drains are required and have been sized for the 0.2% AEP event, for both sites. The following are proposed:

- Site D2 levees: Two levees around the northern and eastern site boundaries to prevent upstream runoff inflow and two levees along the southern boundary (located either side of the proposed drain) were proposed up to a maximum height of 1.3 m, including 300 mm freeboard. The total levee length was 3,300 m.
- Site G1 levees: Approximately 3,400 m long levee with one-way valve at the south-west corner of the site (to drain out internal site flows) was proposed around the site perimeter up to a maximum height of 2.8 m, including 300 mm freeboard.
- Site D2 drain: A 1,200 m long drain with 20 m base width and maximum depth of 2 m was proposed along the southern site boundary.

Flood inundation and velocity mapping was presented to compare the 1% and 0.2% AEP flooding for the existing and proposed site conditions.

3.3.3 Review Comments and Recommendations

The hydrological assessments undertaken for both sites appear to be appropriate and are presented well. Some minor comments and recommendations arising from the hydrology review are presented in Table 4.

Table 4: Review Comments – Hydrology

No.	Comment	Recommended Approach
1	<p><u>DHR, Section 3.5</u></p> <p>The method adopted to generate the storm patterns appears to be sound but different to the ARR recommended approach of using the ARR provided temporal patterns and ARF. Although the adopted method is likely to be more conservative, it may not replicate the actual flood behaviour of the catchment and could overestimate the required flood protection infrastructure.</p> <p>Considering the sizing of the required flood protection infrastructure, it would be helpful to understand the difference of flood results between the adopted approach to generate storm hydrographs and the approach using ARR temporal patterns in combination with ARF.</p> <p>Also, it would be helpful to understand the catchment runoff response for different storm durations if the critical duration analysis results are provided in a graph.</p>	<p>The DHR should provide an explanation of why it did not consider using the ARR recommended temporal patterns and ARF.</p> <p>It would be helpful if DHR provides results of the critical duration analysis for different storm durations in a graph.</p>
2	<p><u>DHR, Section 3.5</u></p> <p>DHR, Section 2.3 and Appendix A provide RFFE model results for both sites but a comparison between the RFFE results and the 2D flood modelling results is not provided. It is noted that the nearest gauged catchment to the site used in the RFFE model is about 300 km away and results may not directly relate to the site. However, it is important to have a results comparison between the two methods in the absence of another method to calibrate/validate the 2D flood model.</p>	<p>The DHR should provide a comparison between RFFE results and the 2D flood modelling results. This will highlight whether the 2D flood modelling results sit between the lower and upper confidence levels arising from the RFFE model.</p>
3	<p><u>DHR, Section 4, SIR G1 and SIR D2, Section 7.5 and SCR, Section 4.4.12</u></p> <p>It would be useful if the basis of design for storm event selection is provided, i.e. any referenced guidelines.</p>	<p>It would be useful if the DHR, SIR and SCR provide the basis of design for storm event selection.</p>
4	<p><u>DHR, Section 5</u></p> <p>It is important to understand the peak flows at the key locations of the site, specifically in regard to the sizing of the proposed infrastructure. Providing these within the report would add value.</p> <p>A comparison of peak flow discharges from the site between existing and proposed conditions is important to assess how the proposed development may impact the hydrology of the downstream environment.</p>	<p>It would be useful if the DHR provides a table with peak flood estimate results at the key locations of the site and for the proposed infrastructure.</p> <p>It would be useful if the DHR provides a comparison of peak flow discharge from the site between existing and proposed conditions.</p>
5	<p><u>SCR, Section 4.4.12</u></p> <p>Details of the proposed stormwater drain associated with Site D2 are not provided.</p> <p>Requirement for a one-way valve at the south-west corner of Site G1 to convey discharge from the site is not noted.</p> <p>For site comparison purposes, it would be beneficial if the required earthworks quantities for the proposed infrastructure are provided for both sites.</p>	<p>The SCR should provide proposed stormwater drain details for Site D2 and requirement for a one-way valve at the levee for Site G1.</p> <p>It would be helpful if the SCR provided required earthwork quantities associated with the proposed infrastructure for both sites.</p>
6	<p><u>SIR G1 and SIR D2, Section 7.5</u></p> <p>SIR recommends “stormwater drainage design should be undertaken in accordance AS 3500.3-2015 Plumbing and drainage, Part 3: Stormwater drainage”. There are additional guidelines applicable for the stormwater infrastructure designs that should be noted e.g. ARR 2019, erosion and scouring protection guidelines and guidelines associated with landfill designs.</p>	<p>Comment, for consideration during detailed design phase.</p>

3.4 Geotechnical Engineering

3.4.1 Reviewer

The geotechnical review was undertaken by David Barrett, Principal Geotechnical Engineer at Golder. David has over 15 years' experience as a geotechnical engineer and has undertaken geotechnical assessments at various landfill sites in Western Australia and New South Wales.

3.4.2 Summary of Information Presented

Geotechnical site investigations were undertaken at sites D2 and G1 to assess subsurface soil and groundwater conditions underlying the sites. The methodology and findings of the investigations are presented in the site investigation reports [SIR-D2 and SIR-G1] and a summary is presented in the SCR.

The geotechnical investigation at D2 Site was conducted during November 2020 and included drilling of 15 boreholes, excavation of 50 test pits, and dynamic cone penetrometer testing.

The geotechnical investigation at G1 Site was conducted during November 2020 and included drilling 11 boreholes, excavation of 50 test pits, and dynamic cone penetrometer testing.

Geotechnical laboratory testing was conducted on samples collected from the test pits and boreholes at both sites. Samples were tested for particle size distribution, Atterberg limits, shrink-swell, permeability, maximum dry density, California bearing ratio, total organic carbon, and cation exchange capacity.

Based on the findings of the geotechnical investigations, the generalised soil profile at both the D2 and G1 sites was described as comprising:

- Silty clayey SAND (Pindan Sand): pale red sand, fine to medium grained, subangular, with trace gravel, of aeolian origin, extending to depths of between 10 m to 15 m bgl (D2) and 9 m to 16 m bgl (G1) overlying
- SANDSTONE (Broome Sandstone): pale yellow to white, very fine to medium grained, variably cemented, bedded to weakly bedded sandstone, very low to low strength.

3.4.3 Review Comments and Recommendations

The geotechnical investigations, as presented in the SIR-D2, SIR-G1 and SCR reports are generally deemed appropriate for the level of investigation required at this stage of the project. Review comments and recommendations are presented in Table 5.

Table 5: Review Comments – Geotechnical Engineering

No.	Comment	Recommended Approach
1	<p><u>SIR-D2 and SIR-G1, Section 7.3:</u> The SIR-D2 and SIR-G1 identifies the presence of Pindan Soils near the ground surface across the site footprint. Pindan soils have been shown to exhibit collapse potential at other sites in the Kimberley.</p> <p>The potential for collapsible soils to be present is not addressed in the SIR.</p> <p>It is noted that the SCR (Section 4.3.2.) describes the Pindan sands as, '<i>although described as collapsible silty-sand or clayey-sand soil it displays a self-cementation property on drying</i>'.</p>	<p>The SIR-D2 and SIR-G1 should be updated to include preliminary discussion on the collapse potential of the soils on site.</p> <p>Further assessment of collapse potential should be undertaken during the detailed design phase.</p>

No.	Comment	Recommended Approach
2	<p><u>SIR-D2 and SIR-G1, Section 7.3</u></p> <p>SIR-D2 and SIR-G1 address earthworks related to construction of buildings with shallow footings approximately <0.5 m. However deeper earthworks and excavation activities have not been discussed.</p> <p>There is no discussion on deeper earthworks, such as that would be expected to be required to construct the landfill cells or leachate pond.</p>	The SIR-D2 and SIR-G1 should be updated to also include preliminary discussion on deeper excavations. The potential for encountering Broome Sandstone within the excavations should also be considered.
3	<p><u>SIR-D2:</u></p> <p>The test pits excavated within the proposed landfill footprint at Site D2 were excavated to a maximum depth of 5 m. The conceptual landfill design shown in Figure 09 indicates that excavations of up to about 6 m depth may be required to construct the landfill cells.</p> <p>There is currently some uncertainty in the geotechnical conditions that will be encountered at the base of the landfill cells and the presence of Broome Sandstone at these depths cannot be completely ruled out.</p> <p>It is noted that the nearest boreholes, GW2-S/D to GW4-S/D, are located approximately 500 m to 700 m away. Therefore, interpolating subsurface conditions within the landfill footprint using this data may not be accurate.</p>	Additional geotechnical investigation will be required during detailed design phase to assess the subsurface conditions in these areas at the base of the landfill cells
3	<p><u>SIR-D2, Figure 07</u></p> <p>Figure 07 (Sample Locations) shows no sample locations within the proposed footprints of the future landfill expansion area, leachate evaporation ponds, weighbridge or community recycling centre (based on the layout presented in the SCR).</p>	Additional geotechnical investigations should be undertaken during detailed design phase to assess the subsurface conditions in these areas.
4	<p><u>SIR-G1, Figure 07</u></p> <p>Figure 07 (Sample Locations) shows no sample locations within the proposed footprints of the future landfill expansion area, the surface water infiltration/collection ponds, the future leachate evaporation pond, commercial weighbridge, and access roads (based on the layout presented in the SCR).</p>	Additional geotechnical investigations should be undertaken during detailed design phase to assess the subsurface conditions in these areas.
5	<p><u>SIR-D2 and SIR-G1, Section 6</u></p> <p>The SIR-D2 and SIR-G1 state that '<i>Shrink/swell testing showed the surficial soils were not subject to a large degree of expansion</i>'.</p> <p>Based on the shrink-swell results presented in Table 6.3, these soils are slightly reactive.</p>	<p>For clarity, SIR-D2 and SIR-G1 should be updated to describe the surficial soils as 'slightly reactive', based on the initial laboratory testing.</p> <p>Additional laboratory testing should be undertaken during detailed design phase to confirm the shrink/swell properties of the surficial Pindan Soils.</p>
6	<p><u>SIR-D2 and SIR-G1, Appendix E</u></p> <p>The SIR-D2 and SIR-G1 state that both shallow (S' into Pindan Sand) and deep (D' into Broome Sandstone) groundwater monitoring wells were drilled and installed at the sites.</p> <p>Only logs for the deep wells are presented in Appendix E. Logs for the shallow wells are not provided.</p>	Logs for the shallow wells, showing geology and well construction details, should be included in Appendix E of the SIR-D2 and SIR-G1.

3.5 Flora and Fauna

3.5.1 Reviewers

The review of the flora and vegetation surveys was undertaken by Dr. Andrew Craigie, Principal Botanist at Ecologia (PhD, B.Sc. (Hons)). Andrew has over 12 years' experience undertaking detailed flora and vegetation surveys in Western Australia, including on the Dampier Peninsula.

The review of the fauna surveys was undertaken by Tim McCabe, Senior Zoologist at Ecologia (B.App.Sc.). Tim has over eight years' experience undertaking fauna assessments in Western Australia, including on the Dampier Peninsula.

3.5.2 Summary of Information Presented

The following flora and fauna studies were undertaken at the two preferred RRRP sites:

- Desktop study (presented in the RFFS, DFVA and TFA)
- Reconnaissance flora and vegetation survey (presented in the RFFS)
- Detailed flora and vegetation survey (presented in the DFVA)
- Level 1 fauna survey (presented in the RFFS)
- Level 2 terrestrial fauna assessment (presented in the TFA).

A brief overview of each of the studies is presented in the following sections.

Desktop study [RFFS, DFVA and TFA]

The desktop study evaluated relevant information relating to the study areas including climate, disturbance history, vegetation, geology, land systems, significant plant species and communities, and relevant flora and vegetation surveys.

Reconnaissance flora and vegetation survey [RFFS]

Reconnaissance surveys are undertaken to provide context and gather broad biological information about a survey area (EPA 2016a). The reconnaissance flora and vegetation survey was undertaken in late November 2019. The survey included a combination of relevés, traverses, and opportunistic sampling to broadly characterise the flora and vegetation of the study areas. The broad floristic composition of the study areas and broad vegetation types were described and mapped. The reconnaissance survey was completed in accordance with the *EPA Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016a).

Detailed flora and vegetation survey [DFVA]

The detailed flora and vegetation survey of the two sites was undertaken in April 2020. The survey included assessment of five 50 m × 50 m quadrats, five relevés, and 45 km of traverses at 100 m spacing. The field survey, subsequent data analysis and interpretation, and vegetation mapping were completed in accordance with the *EPA Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016a).

Level 1 fauna survey [RFFS]

A Level 1 fauna survey was undertaken concurrently with the reconnaissance for flora and vegetation in November 2019 to identify fauna habitats, undertake low-intensity fauna sampling and verify the accuracy of the desktop assessment, with a focus on any conservation significant fauna identified as likely to be present. The desktop assessment identified conservation significant fauna and SRE invertebrate potentially occurring in the area and likelihood of occurrence assessments were undertaken for each species. The Level 1 survey was completed in accordance with the *EPA Technical Guidance: Terrestrial Fauna Surveys* (EPA 2016b).

Level 2 terrestrial fauna assessment [TFA]

The Level 2 terrestrial fauna field survey was undertaken in April 2020. The survey included systematic trapping sites, bird surveys, diurnal opportunistic searches, bat acoustic recording, nocturnal opportunistic searches, and camera trapping. The field survey, subsequent data analysis and interpretation, fauna habitat assessment, conservation significant fauna species likelihood of occurrence and SRE invertebrate fauna assessment was completed in accordance with the EPA *Technical Guidance: Terrestrial Fauna Surveys* (EPA 2016b).

3.5.3 Review Comments and Recommendations

Overall, the reviewers are satisfied that the reconnaissance and detailed flora and vegetation assessments, and Level 1 and Level 2 fauna assessments of the two sites accord with the EPA's Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment and Technical Guidance: Terrestrial Fauna Surveys (EPA, 2016a; EPA, 2016b) and are likely to meet regulatory requirements. The reports sufficiently detail the survey methodology, the survey area, and the process undertaken during the field survey components. No major limitations were identified that would likely negatively affect the results.

Some minor comments, relating to the qualifications of the study teams, are presented in Table 6.

Table 6: Review Comments – Flora and Fauna

No.	Comment	Recommended Approach
1	<u>TFA, Section 2.3.7 & DFVA, Section 2.1</u> Although experienced and possessing the appropriate licences for the surveys, no qualifications for the study teams were provided in the TFA or DVFA reports. The qualifications of all personnel involved should be included in survey reporting in accordance with the EPA's Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a) and the EPA Technical Guidance: Terrestrial Fauna Surveys (EPA 2016b).	Include qualifications of study teams in Table 2.5 of the TFA and Table 2.1 of the DFVA.
2	<u>TFA, General</u> It is the reviewers' understanding that the field survey lead for the Level 2 fauna survey and report co-author (Jordan Voss) does not possess the appropriate tertiary biological qualifications.	Level 2 terrestrial fauna field survey leads and associated reporting personnel should be appropriately qualified

Further comments on the individual study elements are presented in the following sections.

Desktop study [RFFS, DFVA and TFA]

The desktop study provided sufficient background information for the reconnaissance and detailed surveys and was completed in accordance with EPA Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016a).

Reconnaissance flora and vegetation survey [RFFS]

The reconnaissance flora and vegetation survey was undertaken in late November 2019, during the 'supplementary' survey season for flora and vegetation surveys in the Northern Botanical Province according to the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016a). This survey timing is considered appropriate for a reconnaissance flora and vegetation survey.

There were no significant limitations to the reconnaissance survey identified as part of this review.

Detailed flora and vegetation survey [DFVA]

The detailed flora and vegetation survey of the two sites was undertaken in April 2020, following the ‘primary’ or optimal survey season (January to March) for flora and vegetation surveys in the Northern Botanical Province according to the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016a). The timing of the survey is considered appropriate for a detailed flora and vegetation survey on the Dampier Peninsula.

The survey was undertaken by botanists who are sufficiently experienced with the flora and vegetation of the Dampier Peninsula. Given the relatively small size of the survey areas and the apparent homogeneity of the vegetation present (only one vegetation type recorded within both study area, which was represented by four quadrats), sampling effort is considered sufficient to characterise floristic composition and plant communities, and to determine the presence and distribution of significant plant species and communities.

There were no significant limitations to the detailed survey identified as part of this review.

Level 1 fauna survey [RFFS]

The survey timing was appropriate for a Level 1 fauna survey. The report sufficiently details the survey methodology, the survey area, and the process undertaken.

Level 2 terrestrial fauna assessment [TFA]

The Level 2 terrestrial fauna field survey was undertaken in April 2020, just outside the optimal season for fauna surveys for the region (December – March). The survey timing is justified in the report and is considered appropriate for a fauna survey in the Kimberley. The survey was undertaken by zoologists who are sufficiently experienced in conducting fauna survey on the Dampier Peninsula.

Although there are some discrepancies relating to the number of pit trap nights described in the survey methodology and survey effort outlined in Table 2.4 of the TFA, overall survey effort appears adequate to describe fauna species present and likelihood of significant fauna species occurring given the small size of the survey areas.

3.6 Heritage

3.6.1 Reviewer

The heritage review was undertaken by Daniel Bruckner, Senior Anthropologist with over 15 years’ experience in Heritage and Native Title. Daniel is a former Research Fellow at the University of Western Australia and independent advisor to Industry, Native Title Representative Bodies, and Aboriginal Corporations.

3.6.2 Summary of Information Presented

This section of the peer review covers the key elements of the Heritage Survey undertaken by the Consultant and representatives of local Native Title group as presented in the HSR. The HSR identifies the survey area, methodology and survey outcomes. It includes the maps of the survey area and tables with the associated spatial extends of the areas. The survey team itself was not described in any detail.

3.6.3 Review Comments and Recommendations

Overall, the reviewer is satisfied that the HSR report meets industry standard and is highly likely to meet regulatory requirements. The report clearly spells out the applied methodology, the survey area, and the process undertaken during the field survey component. The Department of Planning Land and Heritage (DPLH) register was consulted prior to the fieldwork and the area subject to the report has been adequately covered by pedestrian survey. Even though the survey appeared to finish early, adequate time has been spent in the field to identify any sites of potential significance.

The maps in the report appendix are clear and the coordinate system has been defined as GDA94, which is expected for the purpose of the report. Additional to the maps, polygon information was provided in tabulator format with eastings and northings in the correct projection. No sites have been identified in the report, which makes away with the fact that no specific site recording methodology was included in the document. The only shortcomings of the report are the lack of detail in respect of the participants of the survey, specifically:

- Who selected the participants?
- How are they connected to the survey area and what is their authority to speak for country?
- There is also no background on the Author and the relevant expertise to conduct the survey and associated report.

A minor structural issue is that the report is deemed to be an open report but on page two of the report, under confidentiality and copyright, it appears that the report may contain legal privilege and is hence confidential.

The comments and recommendations arising from the review are presented in Table 7.

Table 7: Review Comments – Heritage

No.	Comment	Recommended Approach
1	<u>HSR, General</u> Lack of detail in relation to the author's qualifications and experience	Include author's qualifications and experience in Section 2.0 of HSR
2	<u>HSR, Section 3.1</u> Lack of detail about the survey participants in relation to their connection to the survey area and their cultural authority	Include additional information under Section 3.1 in the HSR
3	<u>HSR</u> Confusion as to whether the report is confidential or open for public submission.	Clarify under Confidentiality and Copyright

4.0 RESPONSES

Responses to the comments and recommendations included in this Peer Review Report (excluding heritage component) were prepared by the relevant document authors and presented in Talis (2021b). The responses have been tabulated in Appendix A, with an additional column presenting close-out comments from the respective peer reviewers.

5.0 IMPORTANT INFORMATION

Your attention is drawn to the document titled – “Important Information Relating to this Report”, which is included in Appendix B of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder has under the contract between it and its client.

Signature Page

Golder Associates Pty Ltd



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- Talis Consultants (2020a). Broome Regional Resource Recovery Park Site Selection – Hydrology Assessment. Report to Shire of Broome. November 2020. Project Number XXXXX. **[SSHA]**
- Talis Consultants (2020b). Broome Regional Resource Recovery Park Site Selection – Hydrology Assessment. Report to Shire of Broome. 25 November 2020. Project Number XXXXX. **[HA]**
- Talis Consultants (2020c). Site Comparison Report Broome – Regional Resource Recovery Park. Report to Shire of Broome. 3 December 2020. Project Number TW19104. **[SCR]**
- Talis Consultants (2021a). Site Investigation Report – Broome Regional Resource Recovery Park – Site D2. Report to Shire of Broome. 18 January 2021. Project Number TW19118. **[SIR-D2]**
- Talis Consultants (2021b). Site Investigation Report – Broome Regional Resource Recovery Park – Site G1. Report to Shire of Broome. 27 January 2021. Project Number TW19118. **[SIR-G1]**
- Talis Consultants (2021c). Broome RRRP – Peer Review Response. Report to Shire of Broome. 18 February 2021. Project Number TW19104.
- Water Corporation (N/A). Proposed Landfill Broome Cape Leveque Rd (Lot 25716) – Groundwater Source Protection Assessment. Broome Town Water Supply Scheme. Provided to Golder in December 2020. **[GSWA]**

APPENDIX A
Response Table

Table A1: Responses and Close-out Comments

Item	Section	Reviewer Feedback	Recommended Approach	Talis' Response	Reviewer Close-out
Landfill Design					
1	Site Comparison Report – Section 3.2	Cognisance should be taken that the majority of liquid wastes contain hydrocarbons. All the hydrocarbons are unlikely to be removed prior to water being transferred to the evaporation pond, which is to be lined with HDPE. Hydrocarbons are known to be detrimental to the long term performance of HDPE.	The SCR should acknowledge this potential constraint. Further assessment should be undertaken during detailed design phase.	<p>The Shire is currently engaging with various bodies, including waste generators and services providers, to obtain a greater understanding of the exact types and quantities of liquid wastes to be accepted at the facility. The Shire's final select waste streams and quantities to be accepted will need to be approved by the Department of Water and Environmental Regulation (DWER). This information will be utilised as part of the Approvals and Detailed Design phases of the project.</p> <p>HDPE geomembrane has been selected for the primary barrier in the containment systems as it is one of the most chemically resistant geosynthetic lining materials available.</p> <p>HDPE is primarily susceptible to short chain / light range hydrocarbons and organic solvents which have the capability of permeating HDPE geomembrane when in high concentrations or neat form, however this is unlikely to occur during normal operation of the liquid waste facility. Furthermore, HDPE has the ability to maintain its physical strength and tensile capabilities following such exposure.</p> <p>The more aggressive light range hydrocarbons and solvents which are volatilised far easier than the heavy range, will be diluted upon entering the evaporation pond and volatilised during the evaporation of the liquid waste. Any residual heavy range hydrocarbons are by their molecular size, non-challenging to HDPE. This pre-treatment stage will minimise the concentrations of residual hydrocarbons in the solid waste being disposed of in the landfill.</p> <p>It is also important to note that there will be environmental monitoring and inspections of the liquid waste facility and, if required, these ponds can be decommissioned and remediated. As the liquid waste facility is at surface, this is an easy task.</p> <p>Concentrations of hydrocarbons to be accepted within the Class III landfill facility will be condition by the Department of Water and Environmental Regulation in accordance with its Landfill Waste Classification and Waste Definition (as amended 2019) publication.</p>	Approach is acceptable. No further comments.
2	Site Comparison Report – Section 3.3 – Bullet 3	The figure after the description of the capping includes a gas collection and bedding layer, as well as a drainage layer above the geosynthetic capping material.	The SCR description of the capping system should be amended to match the figure	The SCR has been amended as per Golder Associate's feedback.	No further comments.
3	Site Comparison Report – Section 4.2	The site description includes the maximum and minimum site elevations.	The SCR description of the topography should be amended to include the general slope of the site.	The SCR has been amended as per Golder Associate's feedback.	No further comments.
4	Site Investigations Report D2 and G1	No assessment has been included on the in-situ soils available on the site for use in landfill construction.	<p>The SCR should include a preliminary assessment on the suitability of the site soils to be utilised as:</p> <ul style="list-style-type: none"> • Foundation material for the landfill • Attenuation layer below the geosynthetic liner system • Capping materials • Landfill perimeter bund construction <p>We expect further assessment of these aspects will be undertaken during detailed design phase</p>	<p>The primary focus of the geotechnical investigation was to confirm there are no fatal flaws with the underlying geology at both sites in relation to the landfill site development. This has now been confirmed.</p> <p>Preliminary assessment of the site-won soils indicates they will be suitable for these purposes however further detailed assessment of site-won soils will be undertaken during the detailed design and construction phases of the project.</p>	

Item	Section	Reviewer Feedback	Recommended Approach	Talis' Response	Reviewer Close-out
Hydrogeology					
1	Groundwater Source Protection Assessment	The Water Corporation has utilised a calibrated model to assess likely pathways of landfill seepage-affected groundwater. The modelling approach appears to be sound but the assumptions around bore pumping at Water Corporation bores and other bores have not been described.	GSPA should confirm the bore pumping assumptions (sites and rates) used in the model and that this reflects Water Corporation's future pumping plans. The model should consider the results of field investigations at the D2 site and pumping from the proposed production well at D2. GSPA should clearly show the extents of the Water Corporation bore capture zones.	<p>The Water Corporation modelling objective included predicting the scale of changes in groundwater levels in the aquifer under a range of scenarios which included increased pumping rates to 6.2 GL/year to match its planned abstractions. The Water Corporation also advised it has progressively reduced pumping from the southern wells within the TWS due to the potential of saltwater intrusion with future expansion of the borefield expected to occur further to the north and not from existing bores near Site D2.</p> <p>The Water Corporation model was calibrated to long-term data available for the TWS borefield and available data for private abstractions recorded in the Department of Water (DoW), Water Information Reporting (WIR) database. It is noted the dataset included TWS observation bores near D2. As such the modelling depicted a relatively high degree of confidence across the region of the model in which D2 is located, which was confirmed by analysis of observed and predicted residuals following calibration performance metrics in Murray-Darling Basin Commission, Groundwater Flow Modelling Guideline (2000).</p> <p>A subsequent run of the Water Corporation model incorporated particle tracking using the MODPATH package which clearly showed D2 is not within the TWS borefield capture zone. It is recognised there are private abstractions not included in the model including at the Motorplex to the south and tree plantation to the north but these are relatively minor compared to the TWS bores and would not significantly affect the groundwater flow direction at D2.</p> <p>Overall, all data collated by multiple parties specify that groundwater flow direction at D2 is to the south-west such that conclusions regarding potential impact on sensitive receptors are robust.</p> <p>The D2 Site Investigations report has been updated to reflect Golder Associates recommendations.</p>	The clarification provided is satisfactory. This clarification should be presented in the D2 Site Investigations report and/or an updated Water Corporation report (released at an appropriate time).
2	Site Investigations Report D2 and G1 – Section 8	The SIR-D2 and SIR-G1 estimate transmissivity (T) of 1,300 and 194 m ³ /m/day based on the results of water level responses from bores that partially-penetrated the aquifer. Hydraulic conductivity (K) was then estimated to be 9 and 13 m/day (respectively) by dividing T by the full aquifer thicknesses. In both cases, K values and seepage velocity estimates are likely to have been underestimated.	The SIR-D2 & SIR-G1 should re-assess the derivation of hydraulic conductivity to reflect the part of the aquifer tested. This should be cross-checked with Groundwater Source Protection Assessment assumptions.	<p>The results of pumping test analysis and estimation of seepage velocity is required for the assessment of risk posed by migration of landfill leachate. The estimated seepage velocity was 9 and 21 m/year at G1 and D2, respectively. It is noted the hydraulic gradients (<i>i</i>) used in the calculations are near the top of the range given groundwater levels are close to the long term maximum recorded levels (see SIR Section 8.4.1), drawdown is also likely to have been influenced by more permeable horizons at depth with resultant higher values for K based on the assumption of homogeneity in the calculated result. It is also noted the aquifer parameters were consistent with Water Corporation's modelled results including seepage velocity estimates in the range 10 to 13 m/year near D2.</p> <p>Nevertheless, additional conservatism will be included in the assessment and the report has been updated to reflect GA recommendations.</p>	No further comments.
3	Site Investigations Report D2 – Section 10	The SIR-D2 uses the results of field investigations to support the modelling assessment. Once the site is cleared and the landfill is constructed, increasing local recharge rates and changing groundwater flow gradients in the wet season. Importantly, site water supplies are planned to be obtained from a site production well. Potential seepage from the landfill may be captured by this well rather than migrate offsite or be captured by adjacent Water Corporation bores.	The SIR-D2 should assume operation of the production well and re-assess whether potential seepage from the landfill could be collected within the capture zone of the production well.	<p>The exact volume of water to be extracted from the production bore on site is yet to be determined, however it will not be significant. Furthermore, the Shire is looking to capture rainwater and install a tank system on site to further minimise the volume of water that needs to be extracted from the production bore on site.</p> <p>The Shire will be implementing a staged clearing program and only clearing the land required for their immediate infrastructural needs. The Shire will also adopt progressive capping of the landfill with all stormwater generated from the capping system diverted to the stormwater management system on site which discharges to the environment during storm events. Overall, influence of the landfill on the local hydrogeology is insignificant.</p> <p>In relation to the potential influence of the production bore on capturing potential seepage from the landfill, this will be assessed at a later stage during the approvals process but is not being relied on in the risk assessment.</p> <p>The report has been updated based on the above information.</p>	No further comments.

Item	Section	Reviewer Feedback	Recommended Approach	Talis' Response	Reviewer Close-out
4	Site Investigations Report D2 – Section 10	The SIR-D2 uses the results of field investigations (including a single groundwater monitoring event) to support the modelling assessment. The seasonal fluctuations of groundwater conditions at the landfill site should be discussed in the context of potential changes groundwater flow gradients and velocities	The SIR-D2 should discuss seasonal groundwater level fluctuations and whether flow gradients and potential downstream receptors change seasonally.	The groundwater levels gauged across the sites are relatively close to the estimated long-term maximum and therefore the seepage velocities used for calculating contaminant travel times to receptors are at the more conservative end. Nevertheless, the report has been updated to reflect Golder Associates recommendations.	No further comments.
5	Site Investigations Report D2 – Section 10	The SIR-D2 undertakes hydrogeological modelling to assess potential impacts to downstream water quality. Focus has been on ammonia, although other water quality parameters related to landfill seepage are likely to be at elevated concentrations	The SIR-D2 should elaborate further on why focus has been on ammonia and consider assessing potential impacts related to other water quality parameters.	Numerous studies on landfill leachate have shown similarities between sites with chloride and ammonia consistently being the key indicators (Kim and Lee 2009, Robinson 1995, Cozzarelli et al. 2011). Talis has updated the hydrogeological modelling and included chloride and ammonia for Site D2. The report has been updated to reflect GA recommendations.	The response is fine but the report should note these referenced studies (i.e. (Kim and Lee 2009, Robinson 1995, Cozzarelli et al. 2011) as examples of why chloride and ammonia are used here.
6	Site Investigations Report D2 – Section 3	The SIR-D2 makes the statement...."Consistent with the views of Water Corporation, the Broome Town Bore Field is located up hydraulic gradient of the Site and therefore not consider a down hydraulic gradient receptor."	The SIR-DR should describe the Water Corporation's modelling study and its approach (i.e. use of particle tracking approach to assess potential direction of seepage-affected groundwater) rather than statements such as "...with the views of Water Corporation".	Section 3.3 and 3.3.1 of the report has been updated to reflect Golder Associates recommendations.	No further comments.
7	Site Investigations Report G1 – Sections 10 & 11	The SIR-G1 estimates seepage velocity to be 2 m/yr in Section 10 whereas it is estimated to be 21 m/yr in Section 11.	The seepage velocity estimate should be checked and re-assessed.	The seepage velocity value within Section 11 was a typographical error, and the report has been updated accordingly.	No further comments.
8	Site Comparison Report	The study concludes that the risk of potential seepage from the landfill to groundwater is higher at G1 than D2, given that groundwater levels are significant shallower at the G1 site. Specifically, the average minimum depth to water at D2 is 24.15 m (15-31 m range), whereas the average minimum depth to water at G1 is 6.12 m (3-9 m range).	This is an important outcome but is not captured in the individual site investigation reports. It would be helpful that the risk of seepage to groundwater is discussed in these (SIR-D2 & SIR-G1) reports.	The various reports have been updated to reflect Golder Associates recommendations.	No further comments.
Hydrology					
1	Draft Hydrology Report – Section 3.5	The method adopted to generate the storm patterns appears to be sound but different to the ARR recommended approach of using the ARR provided temporal patterns and ARF. Although the adopted method is likely to be more conservative, it may not replicate the actual flood behaviour of the catchment and could overestimate the required flood protection infrastructure. Considering the sizing of the required flood protection infrastructure, it would be helpful to understand the difference of flood results between the adopted approach to generate storm hydrographs and the approach using ARR temporal patterns in combination with ARF. Also, it would be helpful to understand the catchment runoff response for different storm durations if the critical duration analysis results are provided in a graph.	DHR should provide an explanation of why it did not consider using the ARR recommended temporal patterns and ARF. It would be helpful if DHR provides results of the critical duration analysis for different storm durations in a graph.	Adopted method provides a conservative approach for rain-on-grid assessment, particularly for short-duration rainfall across local site areas where no defined drainage paths are present. The Hydrology Report has been updated to include comparison runs using ARR patterns as recommended by Golder Associates. During the detailed design phase of the project, further modelling works will be completed to confirm the surface water infrastructure requirements.	No further comments.

Item	Section	Reviewer Feedback	Recommended Approach	Talis' Response	Reviewer Close-out
2	Draft Hydrology Report – Section 3.5	DHR, Section 2.3 and Appendix A provide RFFE model results for both sites but a comparison between the RFFE results and the 2D flood modelling results is not provided. It is noted that the nearest gauged catchment to the site used in the RFFE model is about 300 km away and results may not directly relate to the site. However, it is important to have a results comparison between the two methods in the absence of another method to calibrate/validate the 2D flood model.	DHR should provide a comparison between RFFE results and the 2D flood modelling results. This will highlight whether the 2D flood modelling results sit between the lower and upper confidence levels arising from the RFFE model.	Comparison table has been added to Section 5 of the report showing the RFFE results, as recommended by Golder Associates.	No further comments.
3	Draft Hydrology Report – Section 4	It would be useful if the basis of design for storm event selection is provided, i.e. any referenced guidelines	It would be useful if DHR, SIR and SCR provide the basis of design for storm event selection	This has been added to the report.	No further comments.
4	Draft Hydrology Report – Section 5	It is important to understand the peak flows at the key locations of the site, specifically in regard to the sizing of the proposed infrastructure. Providing these within the report would add value. A comparison of peak flow discharges from the site between existing and proposed conditions is important to assess how the proposed development may impact the hydrology of the downstream environment.	It would be useful if DHR provides a table with peak flood estimate results at the key locations of the site and for the proposed infrastructure. It would be useful if DHR provides a comparison of peak flow discharge from the site between existing and proposed conditions.	The report has been amended to include the index section locations to plan views with a figure showing the comparison of existing and proposed conditions hydrographs.	No further comments.
5	Site Comparison Report – Section 4.4.12	Details of the proposed stormwater drain associated with Site D2 are not provided. Requirement for a one-way valve at the south-west corner of Site G1 to convey discharge from the site is not noted. For site comparison purposes, it would be beneficial if the required earthworks quantities for the proposed infrastructure are provided for both sites.	SCR should provide proposed stormwater drain details for Site D2 and requirement for a one-way valve at the levee for Site G1. It would be helpful if SCR provided required earthwork quantities associated with the proposed infrastructure for both sites.	The Hydrology Report has been amended to include the earthworks table and conceptual design figures with one-way valve location to plan views.	No further comments.
6	Site Investigations Report D2 and G1 – Section 7.5	SIR recommends “stormwater drainage design should be undertaken in accordance AS 3500.3-2015 Plumbing and drainage, Part 3: Stormwater drainage”. There are additional guidelines applicable for the stormwater infrastructure designs that should be noted e.g. ARR 2019, erosion and scouring protection guidelines and guidelines associated with landfill designs.	Comment, for consideration during detailed design phase.	The reports have been amended to include text stating that additional guidelines will be followed during detailed design with accompanying list.	No further comments.
Geotechnical					
1	Site Investigations Report D2 and G1 – Section 7.3	The SIR-D2 and SIR-G1 identifies the presence of Pindan Soils near the ground surface across the site footprint. Pindan soils have been shown to exhibit collapse potential at other sites in the Kimberley. The potential for collapsible soils to be present is not addressed in the SIR. It is noted that the SCR (Section 4.3.2.) describes the Pindan sands as, ‘although described as collapsible silty-sand or clayey-sand soil it displays a selfcementation property on drying’.	The SIR-D2 and SIR-G1 should be updated to include preliminary discussion on the collapse potential of the soils on site. Further assessment of collapse potential should be undertaken during the detailed design phase.	Both reports have been updated to provide preliminary advice around collapsing soils. Testing, for the collapsing potential of soils, will be undertaken at a later date, during the detailed design stage.	No further comments.

Item	Section	Reviewer Feedback	Recommended Approach	Talis' Response	Reviewer Close-out
2	Site Investigations Report D2 and G1 – Section 7.3	SIR-D2 and SIR-G1 address earthworks related to construction of buildings with shallow footings approximately <0.5 m. However deeper earthworks and excavation activities have not been discussed. There is no discussion on deeper earthworks, such as that would be expected to be required to construct the landfill cells or leachate pond.	The SIR-D2 and SIR-G1 should be updated to also include preliminary discussion on deeper excavations. The potential for encountering Broome Sandstone within the excavations should also be considered.	The primary focus of the geotechnical investigation was to confirm there are no fatal flaws with the underlying geology at both sites in relation to the proposed development. This has been confirmed. The preliminary geotechnical classification provided within these reports targets shallow foundations and footings, such as those for the gatehouse. Geotechnical advice relating to deeper excavations associated with the landfill cells or leachate ponds will be provided at a later stage to support the detailed design phase of the project. A statement highlighting this has been included within the various reports.	No further comments.
3	Site Investigations Report D2	The test pits excavated within the proposed landfill footprint at Site D2 were excavated to a maximum depth of 5 m. The conceptual landfill design shown in Figure 09 indicates that excavations of up to about 6 m depth may be required to construct the landfill cells. There is currently some uncertainty in the geotechnical conditions that will be encountered at the base of the landfill cells and the presence of Broome Sandstone at these depths cannot be completely ruled out. It is noted that the nearest boreholes, GW2-S/D to GW4-S/D, are located approximately 500 m to 700 m away. Therefore, interpolating subsurface conditions within the landfill footprint using this data may not be accurate.	Additional geotechnical investigation will be required during detailed design phase to assess the subsurface conditions in these areas at the base of the landfill cells	Drilling across the Site generally identified homogenous soils, to a depth beyond 6 m bgl, including from the soil bore within the central locations. Whilst the excavations only extended to 5m bgl, the maximum reach of the excavator, it is unlikely that conditions will change between 5 and 6 m bgl-based on conditions encountered within the soils bore. Soil bores, which extended to the Broome Sandstone were utilised in our assessment of the Site. Additional investigations targeting the base of the landfill are not deemed necessary at this stage. However, further geotechnical investigations are planned as part of the detailed design and construction phases of the project.	No further comments.
4	Site Investigations Report D2 – Figure 07	Figure 07 (Sample Locations) shows no sample locations within the proposed footprints of the future landfill expansion area, leachate evaporation ponds, weighbridge or community recycling centre (based on the layout presented in the SCR).	Additional geotechnical investigations should be undertaken during detailed design phase to assess the subsurface conditions in these areas.	Geotechnical works targeting the future landfill cells did not form part of this investigation, and further, confirmatory investigations will be required in this area, at a later date. Similarly, investigations did not directly target the proposed infrastructure, such as the gatehouse. Conditions across the Site can likely be extrapolated with a high degree of confidence, however, limited confirmatory investigations will be required prior to construction of these buildings. Excavations were sunk within the footprint of the first evaporation pond only, the location of the pond for the landfill extension will be determined during the detailed design stage. Further geotechnical investigations are planned as part of the detailed design and construction phases of the project.	No further comments.
5	Site Investigations Report G1 – Figure 07	Figure 07 (Sample Locations) shows no sample locations within the proposed footprints of the future landfill expansion area, the surface water infiltration/collection ponds, the future leachate evaporation pond, commercial weighbridge, and access roads (based on the layout presented in the SCR).	Additional geotechnical investigations should be undertaken during detailed design phase to assess the subsurface conditions in these areas.	The primary focus of the geotechnical investigation was to confirm there are no fatal flaws with the underlying geology at both sites in relation to the proposed development. This has been confirmed. Further geotechnical investigations are planned as part of the detailed design and construction phases of the project.	No further comments.
6	Site Investigations Report D2 and G1 – Section 6	The SIR-D2 and SIR-G1 state that 'Shrink/swell testing showed the surficial soils were not subject to a large degree of expansion'. Based on the shrink-swell results presented in Table 6.3, these soils are slightly reactive.	For clarity, SIR-D2 and SIR-G1 should be updated to describe the surficial soils as 'slightly reactive', based on the initial laboratory testing. Additional laboratory testing should be undertaken during detailed design phase to confirm the shrink/swell properties of the surficial Pindan Soils	Talis acknowledges that the soils are slightly reactive and this has been incorporated into our Site Classification. However, Talis has reworded this statement, highlighting that the soils are slightly reactive. We do not believe that additional geotechnical investigations targeting shrink/swell will be required at a later date and the data, which is consistent across both Sites, is showing homogenous soils across both the areal extent and vertical extent of the proposed development, is sufficient to classify the shrink/swell potential. Additional testing appears to be an unnecessary at this time however this will be given greater consideration at the detailed design stage of the project.	No further comments.
7	Site Investigations Report D2 and G1 – Appendix E	The SIR-D2 and SIR-G1 state that both shallow (S' into Pindan Sand) and deep (D' into Broome Sandstone) groundwater monitoring wells were drilled and installed at the sites. Only logs for the deep wells are presented in Appendix E. Logs for the shallow wells are not provided.	Logs for the shallow wells, showing geology and well construction details, should be included in Appendix E of the SIR-D2 and SIR-G1.	These logs were omitted in error. They have been incorporated into the final report.	No further comments.

Item	Section	Reviewer Feedback	Recommended Approach	Talis' Response	Reviewer Close-out
Flora and Fauna					
1	Terrestrial Fauna Assessment Section 2.3.7 & Detailed Flora and Vegetation Assessment – Section 2.1	Although experienced and possessing the appropriate licences for the surveys, no qualifications for the study teams were provided in the TFA or DVFA reports. The qualifications of all personnel involved should be included in survey reporting in accordance with the EPA's Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a) and the EPA Technical Guidance: Terrestrial Fauna Surveys (EPA 2016b)	Include qualifications of study teams in Table 2.5 of the TFA and Table 2.1 of the DFVA.	<p>We are unsure where exactly it is written in either of the Technical Guidance documents that "qualifications" (we assume they are referring to tertiary qualifications based on comment 2) are required for the survey teams. Searches of the flora guidance fail to detect any use of this term, and the terrestrial fauna guidance indicates that the survey team must be suitably qualified, however there is no indication that tertiary qualifications are required (see below).</p> <p>The Flora and vegetation guidance indicates that "The botanist leading the survey should have at least five years' experience in botanical survey in the bioregion in which the survey is to be conducted. Where the bioregion has been poorly surveyed, the experienced botanist should have more than five years' experience planning and leading surveys in that bioregion".</p> <p>The Terrestrial Fauna guidance indicates that "Fauna and faunal assemblage surveys should be coordinated and led by fauna specialists who have had: a) training, experience and mentoring in the area of fauna identification/fauna and faunal assemblage surveys and/or specific training in elements of survey or sampling theory and Australian fauna identification and zoogeography; and b) would normally have had a wide exposure to WA's fauna and faunal assemblages, preferably with knowledge and experience in the region being surveyed."</p> <p>As indicated in the relevant section of the reports, all survey staff were suitably experienced to complete the field surveys.</p>	<p>Although EPA's Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a) doesn't specifically require survey personnel qualifications to be provided in reporting, it is generally accepted practice in environmental consulting, for the purposes of transparency and to demonstrate survey rigor, for flora and vegetation survey reports to include the qualifications of personnel, along with respective project roles, in the Project Team section of reporting.</p> <p>However, the EPA Technical Guidance: Sampling methods for terrestrial vertebrate fauna (EPA 2016b) does explicitly require that the reporting associated with fauna surveys will include "details of the licences held by relevant survey member and the <u>qualifications</u> and experience of <u>all personnel involved</u>" (see pg. 31 Technical Guidance: Sampling methods for terrestrial vertebrate fauna (EPA 2016b)). The qualifications of the Spectrum fauna team members have not been listed in the associated reporting.</p>

Item	Section	Reviewer Feedback	Recommended Approach	Talis' Response	Reviewer Close-out
2	Terrestrial Fauna Assessment - General	It is the reviewers' understanding that the field survey lead for the Level 2 fauna survey and report co-author (Jordan Vos) does not possess the appropriate tertiary biological qualifications.	Level 2 terrestrial fauna field survey leads and associated reporting personnel should be appropriately qualified	<p>As discussed above there is no requirement for tertiary qualifications within the relevant guidance, and Spectrum is uncertain why the reviewers believe that this is a requirement under the guidance. In our experience, having tertiary qualifications in no way guarantees either experience or ability to complete a fauna survey.</p> <p>Jordan Vos is a highly experienced and respected zoologist that has been working as a zoological consultant continually for over 11 years. Jordan has completed over 70 fauna assessments over that period including over 30 Level 2 surveys, numerous targeted conservation significant fauna assessments and also a variety of SRE invertebrate fauna assessments. Jordan Vos has extensive experience in fauna survey techniques and fauna identification and is a well-respected part of the Australian fauna taxonomy community, with many of his photographs appearing in several field guides including the latest Reptiles of Australia (by Steve Wilson). Jordan Vos also has extensive additional personal fauna experience including working with and advising several PhD researchers. Jordan's extensive experience means that he has also mentored many junior zoologists in both fauna identification and fauna survey techniques.</p> <p>Jordan Vos is in many ways one of the more experienced zoologists in Western Australia and the quality of this field survey is due to his high level of experience.</p>	<p>As per the requirements of the EPA terrestrial fauna survey technical guidance that applied to the fauna surveys at the time when Spectrum undertook Level 1 and 2 fauna surveys of the Broome RRRP survey area in 2019 (ie Technical Guidance: Sampling methods for terrestrial vertebrate fauna (EPA 2016b)) and as stated in Item 1 above, reporting associated with fauna surveys is required to include "details of the licences held by relevant survey member and the qualifications and experience of all personnel involved". Furthermore, the revised EPA technical guidance (EPA 2020) also requires details of the licences held by relevant survey members and the qualifications and experience of all personnel involved to be provided in reporting.</p> <p>While Jordan Vos may be suitably experienced, as is required by the EPA guidance, his qualifications aren't listed in the associated reporting.</p> <p>In the opinion of the reviewer, the absence of a list of qualifications for all Spectrum personnel involved in the fauna surveys, in the fauna reporting, represents a risk to third party scrutiny of the survey reports, particularly as the fauna field lead and reporting co-author isn't suitably qualified.</p>

APPENDIX B

Important Information



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ADDENDUM

BROOME REGIONAL RESOURCE RECOVERY PARK

FLORA AND FAUNA ASSESSMENTS

PREPARED FOR: TALIS CONSULTANTS | SHIRE
OF BROOME



1. SURVEY TEAM EXPERIENCE AND QUALIFICATIONS

The peer review of the detailed flora and vegetation assessment and terrestrial fauna assessment of the Broome Regional Resource Recovery Park (BRRRP) requested additional information regarding the qualifications of the survey team. Below is an updated summary of the key members of the survey team that completed the two reports and attached are CV's for each key staff member outlining relevant qualifications and experience.

Table 1.1: Survey Team and Licences

Staff	Role	Experience	Licences
Flora and Vegetation			
Melissa Hay (Principal Botanist)	Reporting, QA	12 years	-
Chris Parker (Senior Botanist/Ecologist)	Field Assessment, reporting, data analysis	10 years	Flora: FB62000009-2
Chris Shaw (Botanist)	Field Assessment, reporting, data analysis	3 years	Flora: FB62000241
Dr Tim Hammer (Taxonomist/Botanist)	Plant IDs, reporting	5 years	-
Terrestrial Fauna			
Damien Cancilla	Project Management, Report QA	15 years	
Astrid Heidrich	Reporting, Data Analysis	13 years	
Jordan Vos (Zoologist)	Field Assessment, Reporting, Data Analysis	10 years	Fauna: BA27000234
Marcus Cosentino (Zoologist)	Field Assessment	10 years	Fauna: BA27000234
Lauren Butterly (Field Assistant)	Field Assessment (fauna site installation)	-	Fauna: BA27000234
Geoffrey Schoonakker (Field Assistant)	Field Assessment (fauna site installation)	-	Fauna: BA27000234

Damien Cancilla, Manager Biological Sciences | Zoologist



Damien is the Manager of Biological Sciences at Spectrum Ecology, overseeing our flora and fauna capabilities and providing a wealth of technical experience on a wide range of ecological projects. He has been working in the environmental consulting industry since 2006 and has completed an extensive range of zoological assessments across WA, as well as the Northern Territory and Victoria. Damien has managed and conducted multiple large-scale baseline fauna assessments, targeted conservation significant fauna assessments, long-term conservation significant fauna monitoring programs, and managed the completion of several multidisciplinary biological assessments. Damien is an experienced field zoologist and has led large and diverse multi-disciplinary field teams in remote and mining industry settings.

Astrid Heidrich, Principal Zoologist



Astrid is Spectrum Ecology's Principal Zoologist and has worked as a zoological consultant since 2008 managing and completing a variety of fauna assessments across Western Australia as well as in the Northern Territory and Victoria. Over this time Astrid has developed a range of expertise across a variety of fauna survey techniques that she utilises when developing fauna assessment plans for EIA, including baseline assessments, targeted surveys, monitoring programs, remote sensing and habitat mapping. Astrid has also developed a strong understanding of spatial analysis techniques which she employs to assist with data modelling and mapping.

Jordan Vos, Senior Zoologist



Jordan is a well-respected herpetologist with over 20 years' experience working with a variety of reptiles, amphibians and invertebrates and has worked as a zoologist in the environmental consulting industry since 2010. Over that time Jordan has completed almost 100 field surveys including baseline fauna assessments, targeted conservation significant fauna assessments, long-term conservation significant fauna monitoring programs and SRE invertebrate surveys. Jordan's key skills include fauna taxonomy, field assessment and targeted threatened species surveys. He has an excellent knowledge of the fauna of the Pilbara, Midwest, Goldfields, South-west and the Kimberley region.

Melissa Hay, Principal Botanist



Melissa is Spectrum Ecology's Principal Botanist, having worked as a botanist and ecologist in WA's environmental consulting industry since 2006. Melissa is a highly qualified field ecologist, having completed over 100 flora and fauna surveys throughout most regions of WA. Melissa's project experience includes the Pilbara, Midwest, Goldfields, and South-West and includes remote mining and exploration projects to South-West local government and infrastructure projects. Melissa has successfully managed, designed, implemented, and led many small and large-scale surveys for EIA, targeted assessments, and ongoing rehabilitation, weed, and vegetation health monitoring programs. Melissa is very passionate about data management and presentation, quality assurance, and possesses excellent report writing skills in a WA environmental consulting context.

Chris Parker, Principal Spatial Ecologist



Chris has been working in the environmental consulting industry since 2011 where he has developed experience in coordinating and undertaking flora and vegetation surveys and monitoring projects throughout Western Australia. Chris also has extensive experience in combining advanced spatial data analysis techniques and his sound ecological knowledge to analyse and model relationships between flora, fauna and the physical environment. Chris has prior experience in undertaking several vertebrate and invertebrate fauna surveys, as well as conservation significant fauna monitoring projects throughout the Midwest, Wheatbelt/Goldfields, Kimberley and Pilbara regions of WA.

Dr. Chris Shaw, Ecologist | Botanist



Chris worked in research between 2015 and 2020 and casually in the environmental consulting industry since 2017. Chris has developed expertise in the collection and statistical analysis of environmental data sets, including community analyses, multivariate modelling, and distribution modelling. Chris's expertise extends to the identification and the conservation of flora in Western Australia. Chris has contributed to the research and management of plant disease in Western Australia, preparing management and communication documents.

Tim Hammer, Botanist & Taxonomist



Tim is a botanist with extensive knowledge of the Western Australian flora, having conducted numerous surveys throughout the state as a postgraduate and research associate at the Western Australian Herbarium (DBCA) and has 15 peer-reviewed publications since 2014. He is a finishing PhD candidate and Forrest Research Foundation Scholar at The University of Western Australia. He also holds a BSc and MSc from Old Dominion University (USA). Tim also has experience in running MaxEnt distribution models for threatened species. Relevant projects and experience include: Western Australian Herbarium (DPAW) Pilbara targeted *Abutilon*, *Goodenia*, *Ptilotus*, *Tephrosia* & *Triumfetta* surveys (2015) and Northern Territory Herbarium (NT Government) MacDonnell & Central Ranges targeted *Eremophila* & *Ptilotus* surveys (2013)

Appendix A: Staff CVs



DAMIEN CANCILLA

MANAGER BIOLOGICAL SCIENCES



COMPETENCIES

- Field survey design and team management
- Comprehensive and targeted fauna surveys
- Conservation significant fauna monitoring
- Fauna Species Identification
- Experience across several subregion and states
- Extensive experience at active mine sites and remote areas
- ArcGIS mapping

TRAINING

- ICAM incident investigation
- Safety awareness
- Work safely in construction
- Occupancy modelling
- Technical writing
- Provide first aid
- Driver & 4WD competency
- ESRI ArcGIS training

SUMMARY

Damien is the Manager of Biological Sciences at Spectrum Ecology, overseeing our flora and fauna capabilities and providing a wealth of technical experience on a wide range of ecological projects. He has been working in the environmental consulting industry since 2006 and has completed an extensive range of zoological assessments across WA, as well as the Northern Territory and Victoria. Damien has managed and conducted multiple large-scale baseline fauna assessments, targeted conservation significant fauna assessments, long-term conservation significant fauna monitoring programs, and managed the completion of several multidisciplinary biological assessments. Damien is an experienced field zoologist and has led large and diverse multi-disciplinary field teams in remote and mining industry settings.

EDUCATION

BACHELOR OF SCIENCE
(ENVIRONMENTAL SCIENCE & CONSERVATION BIOLOGY) WITH HONOURS
Murdoch University
2002

EMPLOYMENT

MANAGER BIOLOGICAL SCIENCES PRINCIPAL ZOOLOGIST Spectrum Ecology 2018-Present	ASSOCIATE ZOOLOGIST Ecoscape (Australia) 2015-2018	ZOOLOGIST SENIOR ZOOLOGIST Ecologia Environment 2006-2015
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CAREER HIGHLIGHTS

Damien has managed, designed and led field surveys for FMG's annual significant fauna monitoring program since 2012. Including, the continued development of monitoring methods and associated ongoing liaison with relevant DBCA. Species include the Greater Bilby, Ghost and Pilbara Leaf-nosed Bats, Mulgara, Northern Quoll, and Pilbara Olive Python.

Damien undertook and managed large-scale vertebrate fauna assessments of this very challenging, remote project area in the Great Victoria Desert including targeted surveys for the Southern Marsupial Mole and Malleefowl.

Damien conducted Level 2 and targeted fauna surveys for the OPR rail project which spanned over 570 km, and across three IBRA regions of Western Australia. Damien was also responsible for mapping the distribution of the black morph of the Western Spiny Tailed Skink across this region of the Mid-west.

Fortescue Metals Group
Annual Significant Fauna Monitoring
2012 to present

AngloGold Ashanti
Tropicana
Vertebrate Fauna Assessments
2007-2008

Oakajee Port and Rail
OPR Rail Project
Vertebrate Fauna Assessments
2007 to 2010

Fortescue Metals Group
Solomon Hub Project
Vertebrate Fauna Assessments
2014 to 2016

Damien designed, implemented and managed the completion of multiple terrestrial fauna assessments of the Solomon Hub project area. Covering over 180,000 ha, the assessment of the Solomon Hub project included Level 2 baseline surveys and targeted conservation significant fauna surveys.

SELECTED PROJECTS – DAMIEN CANCELLA

Water Corporation Broome Borefield Targeted Greater Bilby Assessment 2020	Murdoch University Harry Butler Institute Terrestrial Fauna Assessment (Level 1) 2020	Norton Gold Fields Binduli North Terrestrial Fauna Assessment (Level 1 & Targeted) 2020
Image Resources Atlas Terrestrial Fauna Assessment (Detailed) 2020	Fortescue Metals Group Fortescue Marsh Waterbird and Migratory Species Assessment 2020	Main Roads Yilgarn Avenue Terrestrial Fauna Assessment (Level 1) 2020
Westgold Resources Ltd Nannine Terrestrial Fauna Assessment (Level 1) 2020	Westgold Resources Ltd Forrest Terrestrial Fauna Assessment (Level 1) 2020	Westgold Resources Ltd Albury Heath & Euro Terrestrial Fauna Assessment (Level 1) 2020
Evolution Mining Rayjax & Castle Hill Terrestrial Fauna Assessment (Level 1) 2020	Department of Justice New Broome Custodial Facility Terrestrial Fauna Assessment (Level 2) 2020	Shire of Broome Regional Resource Recovery Facility Terrestrial Fauna Assessment (Level 2) 2019
Fortescue Metals Group Glacier Valley Terrestrial Fauna Assessment (Level 2) 2020	Fortescue Metals Group Fortescue Marsh Waterbird and Migratory Species Assessment 2020	Fortescue Metals Group DeGrey River Pipeline Terrestrial Fauna Assessment (Level 1) 2020
Image Resources Atlas Project Terrestrial Fauna Assessment (Level 1) 2020	Fortescue Metals Group Kutayi Terrestrial Fauna Assessment (Level 2) 2020	Fortescue Metals Group Raven Terrestrial Fauna Assessment (Level 2) 2019-2020
Fortescue Metals Group Sheila Valley Terrestrial Fauna Assessment (Level 2) 2019-2020	Murdoch University Academic Building Terrestrial Fauna Assessment (Level 1) 2019	Tungsten Mining NL Mt Mulgine Terrestrial Fauna Assessment (Targeted & Level 1) 2019-2020
Fortescue Metals Group/Ironbridge North Star Conservation Significant Fauna Monitoring 2020-2014	Fortescue Metals Group Operational Sites Conservation Significant Fauna Monitoring 2020-2012	Tianye Minjar Sunbeam & Cornishman Vertebrate Fauna Assessment (Targeted) 2020
Fortescue Metals Group Chichester Hub Night Parrot Monitoring 2019	Barra Resources Mt Thirsty Terrestrial Fauna Assessment (Level 1) 2018	Department of Communities West Ellenbrook Level 1 & Targeted Significant Fauna Assessment 2018
Goldfields Power JV Parkeslon Solar Farm Terrestrial Fauna (Level 1) 2019	Shire of Broome Regional Resource Recovery Facility Terrestrial Fauna Assessment (Level 1) 2019	VHM Limited Goschen Project Targeted Significant Fauna Assessment 2019-2018
Adaman Resources Snake Well Terrestrial Fauna Assessment (Level 1) 2019	Fortescue Metals Group Desktop Northern Quoll Artificial Habitat Literature Review 2017	Pilbara Energy Company Pilbara Transmission Project Terrestrial Fauna Assessment (Level 1) 2018
APA Group Badgingarra Wind Farm Carnaby Cockatoo & Bird Mortality Monitoring 2017	APA Group Badgingarra Wind Farm Targeted Fauna Assessment 2017	Fortescue Metals Group Eliwana Targeted Conservation Significant Bat Assessment 2017

SELECTED PROJECTS – DAMIEN CANCELLA

Explaurum/MBS Tampia Targeted Conservation Significant Fauna Assessment 2017	Water Corporation Dunsborough Terrestrial Fauna Assessment (Level 1) 2017	Nyamba Buru Yawuru Pivot Project Terrestrial Fauna Assessment (Level 2) 2017
Fortescue Metals Group Eliwana Ethnobiological Desktop Literature Review 2017	Fortescue Metals Group Desktop Conservation Significant Fauna Habitat Modelling 2016	Citic Pacific Cape Preston Targeted Conservation Significant Fauna Assessment 2016
Fortescue Metals Group Eliwana Consolidated Vertebrate Fauna Assessment (Level 2) 2017	Main Roads Folly Pools Targeted Fauna Assessment: Birds 2016	Citic Pacific Cape Preston Vertebrate Fauna Assessment (Level 1) 2016
Citic Pacific Cape Preston Conservation Significant Fauna Desktop Assessment 2016	Fortescue Metals Group/Ironbridge North Star Targeted Bat Cave Inspection Assessment 2016	Department of Agriculture State Barrier Fence Terrestrial Fauna Assessment 2016
Fortescue Metals Group Cloudbreak Northern Tenements Fauna Habitat Mapping & Targeted Fauna Assessment 2016	Hastings Rare Metals Yangibana Terrestrial & Subterranean Fauna Assessment (Level 2) 2015-2016	Sinosteel Midwest Mungada East Terrestrial Fauna Assessment 2015
Sinosteel Midwest Weld Range Conservation Significant Fauna Clearance Search 2015-2016	Fortescue Metals Group Indibiddi Vertebrate Fauna Assessment (Level 2) 2014	Sheffield Resources Thunderbird Terrestrial & Subterranean Fauna Assessment (Level 2) 2014
Roy Hill Infrastructure Rail Conservation Significant Fauna Monitoring 2015	Fortescue Metals Group Solomon Vertebrate Fauna Assessment (Level 1) 2014	Water Corporation Ellenbrook Vertebrate Fauna Assessment (Level 1) 2013
Sinosteel Midwest Blue Hills Targeted Conservation Significant Fauna Assessment 2014	Green Rock Energy Ocean Hill Vertebrate Fauna Assessment (Level 1) 2013	Fortescue Metals Group/Ironbridge North Star Access Corridor Vertebrate Fauna Assessment (Level 1) 2013
Asia Iron Australia Extension Hill Conservation Significant Fauna Monitoring 2013	Fortescue Metals Group Kutayi Vertebrate Fauna Assessment (Level 2) 2013	Fortescue Metals Group Stingray Terrestrial Fauna Assessment (Level 2) 2013
Fortescue Metals Group Mt Macleod Terrestrial Fauna Assessment (Level 2) 2013	Polaris/MRL Chameleon Terrestrial & Subterranean Fauna Assessment (Level 2) 2013	Fortescue Metals Group Investigator Vertebrate Fauna Assessment (Level 2) 2013
Water Corporation Dandalup Vertebrate Fauna Assessment (Level 1) 2013	Fortescue Metals Group Delphine Vertebrate Fauna Assessment (Level 2) 2013-2012	Fortescue Metals Group Eliwana & Flying Fish Vertebrate Fauna Assessment (Level 2) 2013-2012
Polaris/MRL J4, J5 & Bungabbin East Terrestrial & Subterranean Fauna Assessment (Level 2) 2013	Cape Bouvard Clifton Beach Windfarm Targeted Fauna Assessment: Bird & Bat 2012-2011	Sinosteel Midwest Blue Hills Targeted <i>Idiosoma nigrum</i> Fauna Assessment 2012

SELECTED PROJECTS – DAMIEN CANCELLA

Rio Tinto Greater West Angelas Vertebrate Fauna Assessment (Level 2) 2012	Oil Basins Limited East Blina Flora, Vegetation & Fauna Assessment (Level 1) 2012	Rio Tinto Middle Robe & East Deepdale Vertebrate Fauna Assessment (Level 2) 2012
Cape Bouvard Powerline Corridor Vertebrate Fauna Assessment (Level 1) 2012	Fortescue Metals Group/Ironbridge North Star Vertebrate Fauna Assessment (Level 2) 2012	Hyperion Solar Updraft Tower Vertebrate Fauna Assessment (Level 2) 2012-2011
Fortescue Metals Group Mt Farquhar Vertebrate Fauna Assessment (Level 2) 2012	Blackham Resources Blackham Subterranean Fauna Assessment (Level 2) 2012	Oakajee Port and Rail Oakajee Port & Rail Data Management & Submission 2011
Bogada Gold Bogada Vertebrate Fauna Assessment Level 2 2012	Fortescue Metals Group Central Pilbara Project – Mine Vertebrate Fauna Assessment (Level 2) 2011	Fortescue Metals Group Central Pilbara Project – Rail Vertebrate Fauna Assessment (Level 2) 2011
Zenith Minerals Mt Alexander Terrestrial Fauna Assessment (Level 2) 2012	Rio Tinto Greater Nammuldi Irrigated Agriculture Project Vertebrate Fauna Assessment (Level 2) 2011	Brockman Resources Rail Targeted Conservation Significant Fauna Assessment 2011
Rio Tinto Paraburdoo Area Vertebrate Fauna Assessment (Level 1) 2011	Brockman Resources Marillana Haul Road & Airstrip Terrestrial Fauna Assessment (Level 1) 2011	Rio Tinto Emu to Brolga Rail Duplication Vertebrate Fauna Assessment (Level 2) 2011
Fortescue Metals Group Canning Basin Pipeline & Bore Field Vertebrate Fauna Assessment (Level 1) 2011	Oakajee Port and Rail OPR Rail Regional <i>Egernia stokesii badia</i> Distribution Mapping Assessment 2010	Rules Limesand Lancelin Desktop Fauna Assessment 2010
FASTJV Quarry Infrastructure Northern Quoll Monitoring 2010	Fortescue Metals Group Kings Area Vertebrate Fauna Assessment (Level 2) 2010	Batavia Mining Gorrie Road Vertebrate Fauna Assessment (Level 2) 2010
Brockman Resources Rail Vertebrate Fauna Assessment (Level 2) 2010	Giralia Resources Mt Webber Terrestrial Fauna Assessment (Targeted) 2010	Sinosteel Midwest Elsa Mary Vertebrate Fauna Assessment (Level 1) 2009
Batavia Mining Roper River Vertebrate Fauna Assessment (Level 2) 2010	Ramsay Health Care Joondalup Health Campus Targeted Significant Fauna Assessment 2009	Sinosteel Midwest Robinson Range Terrestrial Fauna Assessment (Level 2) 2009
PPS Dwellingup Pipeline Corridor Targeted Significant Fauna Assessment 2009	Oakajee Port and Rail Oakajee Port & Rail Terrestrial Fauna Assessment (Level 2) 2009-2007	Hancock Prospecting Roy Hill Terrestrial Fauna Assessment 2009-2008
Sinosteel Midwest Jack Hills Vertebrate Fauna Assessment (Level 2) 2009	Hancock Prospecting Roy Hill Southern Rail Spur & Pipeline Corridor Vertebrate Fauna Assessment (Level 1) 2008	Giralia Resources Miss Fairbairn Hills Vertebrate Fauna Assessment (Level 1) 2008

SELECTED PROJECTS – DAMIEN CANCELLA

BHP Billiton
RGP5: Chichester Deviation | Vertebrate Fauna Assessment (Level 1)
2008

Anglo Gold Ashanti
Tropicana | Marsupial Mole Targeted Assessment
2007

Aztec Resources
Koolan Island | Northern Quoll Clearing Programme
2006

Sinosteel Midwest
Weld Range | Vertebrate Fauna Assessment (Level 2)
2007-2008

Aviva
Central West Coal & Coolimba Power Station | Vertebrate Fauna Assessment (Level 2)
2007

Grange Resources
Southdowns Magnetite Project | Vertebrate Fauna Assessment (Level 2)
2006

Anglo Gold Ashanti
Tropicana | Vertebrate Fauna Assessment (Level 2)
2008

Murchison Metals Limited
Jack Hills | Vertebrate Fauna Assessment (Level 2)
2007

Water Corporation
Neerabup MAR | Vertebrate Fauna Assessment (Level 2)
2006

ASTRID HEIDRICH

PRINCIPAL ZOOLOGIST



COMPETENCIES

- Field survey design
- Field team management
- Fauna assessments
- Significant fauna monitoring
- Fauna species identification
- ArcGIS mapping
- Experience across several subregion and states
- Extensive experience at active mine sites & remote areas

TRAINING

- Provide first aid
- Driver & 4WD competency
- Microchipping implantation
- ESRI ArcGIS training
- Occupancy modelling
- Technical writing

SUMMARY

Astrid is Spectrum Ecology's Principal Zoologist and has worked as a zoological consultant since 2008 managing and completing a variety of fauna assessments across Western Australia as well as in the Northern Territory and Victoria. Over this time Astrid has developed a range of expertise across a variety of fauna survey techniques that she utilises when developing fauna assessment plans for EIA, including baseline assessments, targeted surveys, monitoring programs, remote sensing and habitat mapping. Astrid has also developed a strong understanding of spatial analysis techniques which she employs to assist with data modelling and mapping.

EDUCATION

MASTER OF SCIENCE (BIOLOGY) WITH MAJOR IN HERPETOLOGY

Friedrich-Wilhelm-University, Bonn (Germany)
2007

EMPLOYMENT

PRINCIPAL ZOOLOGIST |
SENIOR ZOOLOGIST
Spectrum Ecology
2018-Present

SENIOR ZOOLOGIST
Ecoscape (Australia)
2015-2018

ZOOLOGIST/
SENIOR ZOOLOGIST
Ecologia Environment
2008-2015

CAREER HIGHLIGHTS

Fortescue Metals Group
Annual Significant Fauna Monitoring 2012 to present

Astrid has managed, designed and led field surveys for FMG's annual fauna monitoring program for seven years, which includes systematic trapping, opportunist searches, and radio tracking of individuals. Astrid has been responsible for the data management, analysis and reporting for this long-running project.

Polaris Metals
Yilgarn and Chameleon Project Terrestrial and subterranean fauna 2013

Astrid managed and completed survey work for vertebrate, invertebrate and subterranean fauna at the highly diverse Helena & Aurora Range, including collaboration with expert taxonomists, reporting, mapping and impact assessment.

Oakajee Port and Rail
OPR Rail Project Level 2 and targeted fauna assessments 2009 to 2011

Astrid conducted multiple Level 2 and targeted fauna surveys for the OPR project which included over 570 km of rail inland from Geraldton, across three IBRA regions. Astrid was instrumental in fauna identification, reporting, mapping, and data management for this complex project.

Water Corporation
Various South-west Projects 2007 to 2015

Astrid has completed more than ten projects for the Water Corporation throughout the highly biodiverse south-west region of Western Australia. These projects included comprehensive and targeted fauna assessments, reporting, mapping, and providing advice on environmental issues.

SELECTED PROJECTS – ASTRID HEIDRICH

Main Roads

Yilgarn Avenue | Terrestrial Fauna Assessment (Level 1)
2020

Fortescue Metals Group/Ironbridge

Solomon | Targeted Bat Cave Inspection Assessment
2020

Westgold Resources Ltd

Nannine | Terrestrial Fauna Assessment (Level 1)
2020

Department of Justice

New Broome Custodial Facility | Terrestrial Fauna Assessment (Level 2)
2020

Fortescue Metals Group

DeGrey River Pipeline | Terrestrial Fauna Assessment (Level 1)
2020

Fortescue Metals Group

Raven | Terrestrial Fauna Assessment (Level 2)
2020

Fortescue Metals Group

Operational Sites | Conservation Significant Fauna Monitoring Program
2020-2012

Goldfields Power JV

Parkeston Solar Farm | Terrestrial Fauna (Level 1)
2019

VHM Limited

Exploration Goschen Project | Vertebrate Fauna Assessment
2018

Fortescue Metals Group

Pilbara Olive Python | Desktop Literature Review
2017

Brockman Resources

Services Corridor | Terrestrial Fauna Assessment (Level 2)
2017

Water Corporation

Collie Road Alignment | Terrestrial Fauna Assessment
2017

Evolution Mining

Rayjax & Castle Hill | Terrestrial Fauna Assessment (Level 1)
2020

Westgold Resources Ltd

Forrest | Terrestrial Fauna Assessment (Level 1)
2020

Shire of Broome

Regional Resource Recovery Facility | Terrestrial Fauna Assessment (Level 2)
2019

Tianye | Minjar

Sunbeam & Cornishman | Vertebrate Fauna Assessment (Targeted)
2020

Fortescue Metals Group

Kutayi | Terrestrial Fauna Assessment (Level 2)
2020

Fortescue Metals Group/Ironbridge

North Star | Conservation Significant Fauna Monitoring
2020-2014

Barra Resources

Mt Thirsty | Terrestrial Fauna Assessment (Level 1)
2018

Department of Communities

West Ellenbrook | Level 1 & Targeted Significant Fauna Assessment
2018

Fortescue Metals Group

Desktop | Northern Quoll Artificial Habitat Literature Review
2017

Housing Development

Orelia | Terrestrial Fauna Assessment
2017

Water Corporation

Dunsborough | Terrestrial Fauna Assessment (Level 1)
2017

Fortescue Metals Group

Offset Areas | Fauna Habitat Mapping
2016

Norton Gold Fields

Binduli North | Terrestrial Fauna Assessment (Level 1 & Targeted)
2020

Westgold Resources Ltd

Albury Heath & Euro | Terrestrial Fauna Assessment (Level 1)
2020

Fortescue Metals Group

Glacier Valley | Terrestrial Fauna Assessment (Level 2)
2020

Talis | Murdoch University

Murdoch University | Terrestrial Fauna Assessment (Level 1)
2020

Fortescue Metals Group

Sheila Valley | Terrestrial Fauna Assessment (Level 2)
2020

Tungsten Mining NL

Mt Mulgine | Terrestrial Fauna Assessment (Targeted/Level 1)
2019-2020

Water Corporation | NBY

Broome Borefield | Terrestrial Fauna Assessment (Level 1)
2019

Evolution Mining

Rayjax to Castle Hill | Terrestrial Fauna Assessment (Level 1)
2019

APA Group

Badgingarra Wind Farm | Targeted Fauna Assessment
2017

Nyamba Buru Yawuru

Pivot Project | Terrestrial Fauna Assessment (Level 2)
2017

Water Corporation

Jandakot Clementine Blvd | Terrestrial Fauna Assessment (Level 1)
2017

Citic Pacific

Cape Preston | Conservation Significant Fauna Desktop Assessment
2016

SELECTED PROJECTS – ASTRID HEIDRICH

Water Corporation Various Infrastructure Projects Terrestrial Fauna Assessment 2017-2015	Prism Alliance Burswood Stadium & Rail Targeted Fauna Assessment 2016	Citic Pacific Cape Preston Targeted Northern Quoll Assessment 2016
Fortescue Metals Group/Ironbridge North Star Targeted Bat Cave Inspection Assessment 2016	City of Armadale Roley Pools Terrestrial Fauna Assessment (Level 1) 2016	Department of Agriculture State Barrier Fence Terrestrial Fauna Assessment 2016
Hastings Rare Metals Yangibana Project Terrestrial & Subterranean Fauna Assessment 2016	Main Roads Folly Pools Targeted Fauna Assessment (Birds) 2016	Sinosteel Midwest Weld Range & Blue Hills Targeted Fauna Assessment 2016, 2009
Department of Corrective Services Casuarina & Hakea Prison Vertebrate Fauna Assessment (Level 1) 2016	Fortescue Metals Group Solomon Terrestrial Fauna Assessment (Level 2) 2014	Polaris/MRL Chameleon Terrestrial & Subterranean Fauna Assessment (Level 2) 2013
Sheffield Resources Thunderbird Terrestrial & Subterranean Fauna Assessment (Level 2) 2014	Fortescue Metals Group Eliwana & Flying Fish Vertebrate Fauna Assessment 2013	Fortescue Metals Group Investigator Vertebrate Fauna Assessment 2013
Polaris/MRL J4, J5 & Bungabbin East Terrestrial & Subterranean Fauna Assessment 2013	Fortescue Metals Group Stingray Terrestrial Fauna Assessment (Level 2) 2013	Water Corporation Kondinin Terrestrial Fauna Assessment 2013
Fortescue Metals Group Mt Macleod Terrestrial Fauna Assessment (Level 2) 2013	Fortescue Metals Group/Ironbridge North Star Terrestrial Fauna Assessment (Level 2) 2012	Hyperion Solar Updraft Tower Terrestrial Fauna Assessment (Level 2) 2012
Water Corporation Byford Vertebrate Fauna Assessment 2013	Rio Tinto Middle Robe & East Deepdale Vertebrate Fauna Assessment (Level 2) 2012	Zenith Minerals Mt Alexander Vertebrate Fauna Assessment (Level 2) 2012
Rio Tinto Greater West Angelas Vertebrate Fauna Assessment (Level 2) 2012	Brockman Resources Rail Targeted Fauna Assessment 2011	Brockman Resources Marillana Haul Road & Airstrip Vertebrate Fauna Assessment (Level 2) 2011
Oakajee Port and Rail Oakajee Port & Rail Data Management & Submission 2011	Fortescue Metals Group Central Pilbara Project – Mine Vertebrate Fauna Assessment (Level 2) 2011	Fortescue Metals Group Central Pilbara Project – Rail Terrestrial Fauna Assessment (Level 2) 2011
Fortescue Metals Group Canning Basin Pipeline & Bore Field Vertebrate Fauna Assessment (Level 1) 2011	Rules Limesand Lancelin Desktop Fauna Assessment 2010	Batavia Mining Gorrie Road Vertebrate Fauna Assessment (Level 2) 2010
Norwest Energy Arrowsmith Vertebrate Fauna Assessment (Level 1) 2011	Giralia Resources Mt Webber Vertebrate Fauna Assessment (Targeted) 2010	Oakajee Port and Rail Oakajee Port & Rail Vertebrate Fauna Assessment (Level 2) 2010-2009

SELECTED PROJECTS – ASTRID HEIDRICH

Fortescue Metals Group

Solomon Kings Area | Vertebrate Fauna Assessment
2010

Hancock Prospecting

Murray's Hill | Vertebrate Fauna Assessment (Level 2)
2008

Hancock Prospecting

Roy Hill | Vertebrate Fauna Assessment (Level 2)
2009-2008

Sinosteel Midwest

Robinson Range | Vertebrate Fauna Assessment (Level 2)
2009

FerrAus

Robertson Range | Vertebrate Fauna Assessment (Level 2)
2008

MELISSA HAY

PRINCIPAL BOTANIST



COMPETENCIES

- Field survey design
- Field team management
- Flora assessments
- Fauna assessments
- Rehabilitation monitoring
- Vegetation monitoring
- Database management
- Pilbara experience
- Mid-west experience
- South-west experience
- ArcGIS mapping
- Extensive experience at active mine sites and remote areas

TRAINING

- Provide first aid
- Driver & 4WD competency
- Rescue diver training
- Plant pressure bomb
- Hand held spectrometer
- Fire response
- Landscape function analysis

SUMMARY

Melissa has worked as a botanist and ecologist since 2006 completing over 90 flora, vertebrate and invertebrate fauna surveys throughout Western Australia. Melissa has successfully managed, designed, implemented and led many small and large-scale surveys for environmental impact assessment, ongoing vegetation and rehabilitation monitoring programs and targeted searches.

EDUCATION

BACHELOR OF SCIENCE
(ENVIRONMENTAL BIOLOGY) WITH HONORS
Curtin University of Technology
2005

EMPLOYMENT

SENIOR ECOLOGIST
Spectrum Ecology
2017-Present

SENIOR CONTRACT BOTANIST
Various Consultants
2010-2017

BOTANIST/SENIOR BOTANIST
Ecologia Environment
2006-2016

CAREER HIGHLIGHTS

Oakajee Port and Rail
OPR Project
2006 to 2012

Fortescue Metals Group
Solomon Hub Project
2014 to 2016

Melissa designed, implemented, managed and led several field surveys for flora and fauna over multiple years for the OPR rail project. This project spanned over 570 km across three IBRA regions through the remote areas of the Mid-west. Melissa was responsible for the data analysis, reporting and vegetation mapping for this large and complex project.

Melissa has been involved in many aspects of the Solomon Hub project, including the large consolidation of flora and vegetation surveys, rehabilitation monitoring, water draw down monitoring, LFA analysis and regional searches for restricted flora species and vegetation communities.

BHP Billiton Iron Ore
Rapid Growth Project
5: Rail Duplication
2007

Tronox
Cataby Mineral Sands Project
2012 to 2017

Melissa designed, implemented and led flora and vegetation surveys for many of the RGP5 rail duplication projects across some of the largest active mine sites and rail systems of the Pilbara region. Melissa was also responsible for data analysis, interpretation and reporting for these projects.

Melissa has been involved with the Tronox rehabilitation monitoring program since 2012. This is one of the most botanically diverse regions in Western Australia with very complex species and vegetation communities.

SELECTED PROJECTS – MELISSA HAY

Tungsten Mining Mt Mulgine Detailed flora and vegetation assessment 2020	BHP Billiton Weeli Wollie Spring PEC Extent Mapping 2020	Fortescue Metals Group Solomon Hub Rehabilitation Monitoring 2019-2020
BHP Billiton Jimbabar Creek Rehabilitation Monitoring and Baseline 2019	BHP Billiton Eastern and Central Mines and Chichester Deviation Rehabilitation Monitoring 2019	Barra Resources Mt Thirsty Flora & Vegetation Assessment (Reconnaissance) 2018
Adamant Resources Snake Well Flora & Vegetation Assessment (Reconnaissance) 2018	BHP Billiton BHP Rehabilitation Monitoring 2018	BHP Billiton BHP Rehabilitation Seed Mix Review 2018
Fortescue Metals Group/Ironbridge North Star Significant Fauna Monitoring 2018	Fortescue Metals Group Eliwana Targeted Restricted Vegetation Community Assessment 2018	Chevron Gorgon Project Targeted Weed Assessment 2018
AWE Dongara Production Facility Seed Collection 2017	Hanson Construction Gnangara & Gingin Rehabilitation Monitoring 2017	Tronox Cataby Rehabilitation Monitoring 2017
Mineral Resources Carina Mine Rehabilitation Monitoring 2017	Water Corporation Perth Wetlands Vegetation Health Monitoring 2017	Main Roads North-west Coastal Highway Flora & Vegetation Assessment (Level 2) 2017
Rio Tinto Hope Downs Flora & Vegetation Assessment (Level 2) 2017	Fortescue Metals Group/Ironbridge North Star Water Corridor Targeted Flora & Vegetation Assessment 2016	Fortescue Metals Group Solomon Targeted Regional Flora Assessment 2016
Tronox Cataby Rehabilitation Monitoring 2015	Mineral Resources Carina Mine Rehabilitation Monitoring 2015	Fortescue Metals Group Karijini Flora & Vegetation Assessment (Level 2) & Riparian Vegetation Monitoring 2015
Mineral Resources Bulk Ore Transport System Targeted Flora, Vegetation & Fauna Assessment 2015	Fortescue Metals Group/Ironbridge North Star Targeted Flora & Vegetation Assessment 2015	Aurizon West Pilbara Iron Ore Project Targeted Flora Assessment 2015
Sinosteel Midwest Jack Hills Targeted Flora Assessment 2015	Polaris/MRL J4, J5 & Bungabbin East Targeted Flora Assessment 2015	Toro Energy Wiluna Uranium Project Flora & Vegetation Assessment (Level 2) 2015
Fortescue Metals Group/Ironbridge North Star Flora, Vegetation & Fauna Assessment 2015	Fortescue Metals Group Solomon Rehabilitation Monitoring & Landscape Function Analysis 2014	Fortescue Metals Group Solomon Rail Mulga & Ant Community Monitoring 2014
Fortescue Metals Group Rail Significant Fauna Monitoring 2014	Toro Energy Wiluna Uranium Project Targeted Flora Tecticornia Assessment 2014	Sinosteel Midwest Dead Goat Hill Targeted Flora Assessment 2014

SELECTED PROJECTS – MELISSA HAY

Westralia Iron Koolanooka South Flora & Vegetation Assessment (Level 2) 2014	Fortescue Metals Group Solomon Flora & Vegetation Assessment (Level 2) 2014	Polaris/MRL J5 & Bungabbin East Flora & Vegetation Assessment (Level 2) 2014
Water Corporation Bullsbrook Pump Station Flora, Vegetation & Fauna Assessment 2014	Tronox Cataby Rehabilitation Monitoring 2013	Atlas Iron Pardoo Riparian Vegetation Health Monitoring 2013
Iluka Resources Rare Orchid Targeted Flora Assessment 2013	Iluka Resources Rare Orchid Targeted Flora Assessment 2013	Water Corporation Kondinin Flora & Vegetation (Level 2) & Fauna (Level 1) Assessment 2013
Atlas Iron Pardoo Rail Corridor Flora & Vegetation Assessment (Level 2) 2013	Cliffs Natural Resources Koolyanobbing Flora & Vegetation Assessment (Level 2) 2013	BHP Billiton Area C Extension Flora & Vegetation Assessment (Level 2) 2013
Polaris/MRL J5 & Bungabbin East Flora & Vegetation Assessment (Level 2) 2013	Tronox Cataby Rehabilitation Monitoring 2012	Tronox Cataby Flora & Vegetation Assessment (Level 2) 2012
Fortescue Metals Group Turee Creek Flora & Vegetation Assessment (Level 2) 2012	Origin Energy Dongara Targeted Flora Assessment 2011	Mount Magnet South Mount Magnet Targeted Idiosoma nigrum Assessment 2011
Rio Tinto Paraburdoo Mine Vertebrate Fauna Assessment (Level 1) 2011	Rio Tinto Emu to Brolga Rail Duplication Vertebrate Fauna Assessment (Level 2) 2011	Oakajee Port and Rail Oakajee Port & Rail Targeted Flora Assessment 2010
Oakajee Port and Rail Oakajee Port & Rail Targeted Flora Assessment 2010	Oakajee Port and Rail Oakajee Port & Rail Targeted Flora Assessment 2010	Brockman Resources Marillana Rail Flora & Vegetation Assessment (Level 2) 2010
Brockman Resources Marillana Rail Flora & Vegetation Assessment (Level 2) 2010	Brockman Resources Marillana Services Corridor Flora & Vegetation Assessment (Level 2) 2010	Giralia Resources Mount Webber Flora & Vegetation Assessment (Level 2) 2010
Hancock Prospecting Ethel Creek, East Angelas & Roy Hill Targeted Flora Assessment 2009	Hancock Prospecting Roy Hill Targeted Habitat Assessment 2009	Giralia Resources Miss Fairbairn Hills Targeted Flora Assessment 2009
Giralia Resources Weld Range Giralia Targeted Flora Assessment 2009	Sinosteel Midwest Weld Range Exploration Targeted Flora Assessment 2009	Sinosteel Midwest Weld Range Exploration Targeted Flora Assessment 2009
Oakajee Port and Rail Oakajee Port & Rail Flora & Vegetation Assessment (Level 2) 2009	Hancock Prospecting Roy Hill Targeted Flora Assessment 2008	Hancock Prospecting Roy Hill, Marillana, Ethel Creek Targeted Flora Assessment 2008

SELECTED PROJECTS – MELISSA HAY

Giralia Resources

Miss Fairbairn Hills | Targeted Flora Assessment
2008

Brockman Resources

Marillana | Flora & Vegetation Assessment (Level 2)
2008

Murchison Metals

Mount Hale | Targeted Flora Assessment
2007

Sinosteel Midwest

Weld Range W33 to W40 | Targeted Flora Assessment
2007

BHP Billiton

RGP5: Kurrajurra to Cowra | Flora & Vegetation Assessment (Level 2)
2007

FerrAus

Davidson Creek | Flora & Vegetation Assessment (Level 2)
2007

Midwest Corporation

Koolanooka & Blue Hills | Flora & Vegetation Assessment (Level 2)
2007

Hancock Prospecting

Mulga Downs | Targeted Flora Assessment
2006

Sinosteel Midwest

Weld Range Beebyn & W14 | Targeted Flora Assessment
2006

Giralia Resources

Weld Range Beebynganna | Targeted Flora Assessment
2008

Independent Group

Holleton & Dalwallinu | Targeted Flora Assessment
2007

Sinosteel Midwest

Weld Range Beebyn & Madoonga | Targeted Flora Assessment
2007

Anglo Gold Ashanti

Tropicana | Targeted Flora Assessment
2007

BHP Billiton

RGP5: Yandi to Kurrajurra | Flora & Vegetation Assessment (Level 2)
2007

FerrAus

Robertson Range | Flora & Vegetation Assessment (Level 2)
2007

Sinosteel Midwest

Weld Range | Flora & Vegetation Assessment (Level 2)
2007

Murchison Metals

Weld Range North | Targeted Flora Assessment
2006

Oakajee Port and Rail

Oakajee Port & Rail | Flora & Vegetation Assessment (Level 2)
2006

Sinosteel Midwest

Weld Range Madoonga | Targeted Flora Assessment
2008

Hancock Prospecting

Round Hill Extended | Targeted Flora Assessment
2007

Sinosteel Midwest

Weld Range The Gap | Targeted Flora Assessment
2007

BHP Billiton

RGP5: Chichester Deviation | Flora & Vegetation Assessment (Level 2)
2007

BHP Billiton

RGP5: Newman to Jimblebar | Flora & Vegetation Assessment (Level 2)
2007

FerrAus

Robertson Range Haul Road | Flora & Vegetation Assessment (Level 2)
2007

Anglo Gold Ashanti

Cable Haul Road | Flora & Vegetation Assessment (Level 2)
2007

Sinosteel Midwest

Weld Range | Targeted Flora Assessment
2006

CHRIS PARKER

PRINCIPAL SPATIAL ECOLOGIST



COMPETENCIES

Remote sensing analysis from satellite and aerial imagery

Flora and fauna habitat analysis and modelling

GIS mapping and analysis

Flora assessments

Fauna assessments

Significant fauna monitoring

Rehabilitation monitoring

TRAINING

Provide first aid

Construction white card

Driver & 4WD competency

Remote pilot licence

Aeronautical radio operator certificate

ESRI ArcGIS training

Technical writing

Landscape function analysis

Spectrometer

Plant pressure chamber

SUMMARY

Chris has been working in the environmental consulting industry since 2011 and has developed expertise in advanced spatial data analysis techniques using a variety of remote sensing approaches, incorporating the use of data from satellites, conventional aircraft and drones. Chris's expertise extends to the development of spatially-explicit models exploring relationships between flora, fauna and the physical environment. Chris also has extensive experience in coordinating and undertaking flora and vegetation surveys, fauna surveys and ecological monitoring projects throughout Western Australia, including the Kimberley, Pilbara, Mid-west, Goldfields and South-west.

EDUCATION

MASTERS OF SCIENCE (GEOSPATIAL SCIENCE)

Curtin University of Technology
2016-Present

BACHELOR OF SCIENCE (AQUATIC SCIENCE)

Curtin University of Technology
2009

EMPLOYMENT

SPATIAL ECOLOGIST

Spectrum Ecology
2018-Present

GIS OFFICER

Nyamba Buru Yawuru
2016-2018

SPATIAL ECOLOGIST

Ecoscape Australia
2015-2016

CAREER HIGHLIGHTS

Fortescue Metals Group

Solomon Hub
Flora and Vegetation Assessments
2012 to 2015

Chris was a team leader for the multiple-phase Level 2 flora and vegetation assessment and targeted significant flora survey over the 180,000 ha Solomon project. Chris was also responsible for consolidating and mapping the complex vegetation of the area, including the delineation of Threatened and Priority Ecological Communities of the Hamersley Range.

Origin Energy/RPS

Dongara
Targeted Flora Assessments 2011

Chris lead a team of botanists on a targeted flora survey throughout a large area of one of the most botanically diverse regions in WA, which resulted in a considerable increase in the known population of a Threatened orchid.

Fortescue Metals Group

Annual Significant Fauna Monitoring
2013 to 2018

Chris has been heavily involved in FMG's annual fauna monitoring program for six years. Chris's involvement includes systematic trapping and opportunist searches for conservation significant vertebrate fauna species such as the Northern Quoll, Mulgara and Pilbara Olive Python.

Nyamba Buru Yawuru

Multispectral Vegetation Health Analysis
2017 to 2018

Chris was instrumental in assisting NBY develop a range of new capabilities, such as monitoring of culturally significant wetlands to assess the success of cattle exclusion fencing. Multispectral imagery from drone-mounted sensors was captured over the wetlands and analysis undertaken to discern seasonal variation in vegetation health as well as long-term ecosystem recovery.

SELECTED PROJECTS – CHRIS PARKER

BHP Billiton	Tianye / Minjar Gold Pty Ltd	Murdoch University
BHP Rehabilitation Monitoring 2020	Southern Cross Flora & Fauna Assessment (Level 1) 2019	Murdoch Flora Assessment (Level 1) 2019
Tianye / Minjar Gold Pty Ltd	BHP Billiton	Fortescue Metals Group
Southern Cross Rehabilitation Monitoring 2019	BHP Rehabilitation Monitoring 2019	Cloudbreak Rehabilitation Monitoring & Landscape Function Analysis 2019
BHP Billiton	Nyamba Buru Yawuru	Fortescue Metals Group
BHP Rehabilitation Monitoring 2018	Pivot Project Flora & Vegetation Assessment 2017	Christmas Creek & Cloudbreak Weed Monitoring 2016
Fortescue Metals Group	City of Wanneroo	Hastings Rare Metals
Rail Eliwana to Solomon Targeted Flora Assessment 2016	Landsdale Park Flora & Fauna Assessment (Level 1) 2015	Yangibana Flora, Vegetation, Fauna and SRE Assessment (Level 2) 2015
City of Wanneroo	Westralia Iron	Fortescue Metals Group
Quinns Rocks Caravan Park Flora & Fauna Assessment (Level 1) 2015	Koolanooka South Flora & Vegetation Assessment (Level 2) 2014	Solomon Rehabilitation Monitoring & Landscape Function Analysis 2014
Munglinup Graphite	Mount Gibson	Fortescue Metals Group
Munglinup Flora, Vegetation & Fauna Assessment (Level 2) 2014	Mount Gibson Shine Haul Road Flora & Vegetation Assessment (Level 2) 2014	Solomon Flora & Vegetation Assessment (Level 2) 2014
City of Canning	Sheffield Resources	Toro Energy
Canning River Foreshore Flora & Vegetation Assessment 2014	Thunderbird Project Flora & Vegetation Assessment 2014	Millipede to Lake Maitland & Haul Road Flora, Vegetation & Fauna Assessment (Level 2) 2014
Fortescue Metals Group	Polaris/MRL	Fortescue Metals Group
Fig Tree Flora & Vegetation Assessment 2014	Chameleon Flora & Vegetation Assessment (Level 2) 2013	Solomon Rail Mulga & Ant Community Monitoring 2013
Main Roads	Fortescue Metals Group	Fortescue Metals Group
Victoria Park Avenue Flora & Fauna Assessment (Level 1) 2013	Stingray & Investigator Flora & Vegetation Assessment (Level 2) 2013	Kutayi Flora & Vegetation Assessment 2013
Polaris/MRL	Fortescue Metals Group	Fortescue Metals Group
J5 & Bungabin East Flora & Vegetation Assessment (Level 2) 2013	Mt Macleod Flora & Vegetation Assessment 2013	Solomon South Flora & Vegetation Assessment 2013
Woodside	Polaris/MRL	Fortescue Metals Group
James Price Point Vegetation Monitoring - Wet Season 2012	J4 & Haul Road Targeted Flora Assessment 2012	Turee Creek Flora & Vegetation Assessment (Level 2) 2012
Fortescue Metals Group	Polaris/MRL	Rio Tinto
Turner Syncline Flora & Vegetation Assessment (Level 2) 2012	Helena & Aurora Range & Jackson Range Flora & Vegetation Assessment (Level 2) 2012	Middle Robe & East Deepdale Flora & Vegetation Assessment (Level 2) 2012
Rio Tinto	Woodside	Fortescue Metals Group/Ironbridge
West Angelas Flora & Vegetation Assessment 2012	James Price Point Vegetation Monitoring - Dry Season 2011	North Star Canning Basin Borefield Flora & Vegetation Assessment (Level 1) 2011

JORDAN VOS

SENIOR ZOOLOGIST



COMPETENCIES

- Comprehensive and targeted fauna surveys
- Conservation significant fauna monitoring
- Fauna species identification
- Experience across several subregion and states
- Extensive experience at active mine sites and remote areas
- Terrestrial fauna taxonomy

TRAINING

- Work safely in construction
- Provide first aid
- Driver & 4WD competency
- Venomous snake handling
- Elevated Work Platform license

SUMMARY

Jordan is a well-respected herpetologist with over 20 years' experience working with a variety of reptiles, amphibians and invertebrates and has worked as a zoologist in the environmental consulting industry since 2010. Over that time Jordan has completed almost 100 field surveys including baseline fauna assessments, targeted conservation significant fauna assessments, long-term conservation significant fauna monitoring programs and SRE invertebrate surveys. Jordan's key skills include fauna taxonomy, field assessment and targeted threatened species surveys. He has an excellent knowledge of the fauna of the Pilbara, Midwest, Goldfields, South-west and the Kimberley region.

EXPERIENCE

Jordan is a well-respected herpetologist with over 20 years' experience working with a variety of reptiles, amphibians and invertebrates. Jordan's experience and technical knowledge has allowed him to assist a variety of university researchers working with venomous reptile species including current research into toxic accumulation in apex reptile predators.

EMPLOYMENT

**SENIOR ZOOLOGIST |
ZOOLOGIST**
Spectrum Ecology
2019-Present

ZOOLOGIST
Ecoscape (Australia)
2017-2019

ZOOLOGIST
Ecologia Environment
2011-2015

CAREER HIGHLIGHTS

Fortescue Metals Group
Annual Significant Fauna Monitoring
2012 to present

Fortescue Metals Group
Western Hub Project
Vertebrate Fauna Assessments
2012 to 2013

Polaris Metals
Yilgarn and Chameleon Project
Terrestrial and subterranean fauna
2013

APA Group
Badgingarra Windfarm Carnaby's Cockatoo Monitoring
2017-2019

Jordan has been part of FMG's annual significant fauna monitoring program since 2012. Jordan has experience collecting morphometric data and DNA samples. Species include the Greater Bilby, Ghost Bat, Pilbara Leaf-nosed Bats, Mulgara, Northern Quoll, and Pilbara Olive Python.

The Western Hub Project incorporated multiple terrestrial fauna assessments over the Eliwana, Flying Fish, Delphine and Mt Farquhar project areas. Covering over 300,000 ha, the assessment of the Western Hub project included Level 2 baseline surveys and targeted conservation significant fauna surveys.

Jordan completed survey work for vertebrate, invertebrate and subterranean fauna at the highly diverse Helena & Aurora Range, including Level 2 vertebrate and SRE invertebrate surveys, targeted conservation significant fauna surveys and subterranean fauna sampling.

Jordan completed ongoing monitoring of impacts to fauna from the construction and operation of the Badgingarra Windfarm. Of particular importance was monitoring Carnaby's Cockatoo populations that utilise the region surrounding the Badgingarra Windfarm.

SELECTED PROJECTS – JORDAN VOS

<p>Fortescue Metals Group Glacier Valley Terrestrial Fauna Assessment (Level 2) 2020</p> <p>Image Resources Atlas Project Terrestrial Fauna Assessment (Level 1) 2020</p> <p>Fortescue Metals Group Sheila Valley Terrestrial Fauna Assessment (Level 2) 2019-2020</p> <p>Shire of Broome Broome Reconnaissance Flora & Level 1 Fauna Survey 2020</p> <p>Tungsten Mining Mt Mulgine Significant Fauna Monitoring 2019</p> <p>APA Group Badgingarra Windfarm Carnaby's Cockatoo & Bird Mortality Monitoring 2019-2017</p> <p>Fortescue Metals Group/Ironbridge North Star Significant Fauna Monitoring 2019/ 2017-2014</p> <p>Fortescue Metals Group Eliwana Vegetation Health Monitoring 2019</p> <p>City of Wanneroo Mather Reserve Kangaroo Abundance Assessment 2019</p> <p>Cosmic Resources Irishtown Sandstone Quarry Red-tailed Black Cockatoo Habitat Assessment 2018</p> <p>Minderoo Group Lighthouse Caravan Park Level 1 & Targeted Significant Fauna Assessment 2018</p>	<p>Department of Justice New Broome Custodial Facility Terrestrial Fauna Assessment (Level 2) 2020</p> <p>Water Corporation Broome Borefield Targeted Greater Bilby Assessment 2020</p> <p>Fortescue Metals Group Kutayi Terrestrial Fauna Assessment (Level 2) 2020</p> <p>Image Resources Atlas Terrestrial Fauna Assessment (Detailed) 2020</p> <p>Fortescue Metals Group Solomon Hub Pilbara Olive Python Significant Fauna Monitoring 2019-2020</p> <p>Newmont Australia & TransAlta Energy Kalgoorlie Detailed Flora and Vegetation Assessment and a Level 1 Fauna Assessment 2019</p> <p>Pacific Hydro Australia Argyle to Savannah Transmission Line Level 1 & Targeted Significant Fauna Assessment 2019</p> <p>Fortescue Metals Group Chichester Hub, Solomon Hub & Rail Infrastructure Significant Fauna Monitoring 2019/ 2017-2012</p> <p>Element 25 Butcherbird Manganese Project Level 2 Terrestrial & Short Range Endemic Fauna Assessment 2019</p> <p>Advisian Onslow Pipeline Level 1 & Targeted Significant Fauna Assessment 2018</p> <p>City of Melville Booragoon and Blue Gum Lakes Level 2 Terrestrial Fauna Assessment 2018</p>	<p>Shire of Broome Regional Resource Recovery Facility Terrestrial Fauna Assessment (Level 2) 2019</p> <p>Fortescue Metals Group DeGrey River Pipeline Terrestrial Fauna Assessment (Level 1) 2020</p> <p>Fortescue Metals Group Raven Terrestrial Fauna Assessment (Level 2) 2019-2020</p> <p>Tungsten Mining NL Mt Mulgine Terrestrial Fauna Assessment (Targeted & Level 1) 2019-2020</p> <p>Fortescue Metals Group Sheila Valley & Raven Terrestrial Fauna Assessment 2019</p> <p>Fortescue Metals Group Eliwana mine & Main Line Rail Pilbara Olive Python Significant Fauna Monitoring 2019</p> <p>Covalent Lithium Mt Holland Project Chuditch Monitoring 2019</p> <p>Gambara Reid Highway Expansion Quenda and Other Fauna Translocation 2019</p> <p>Fortescue Metals Group Chichester Hub Temporary Presence of Water Fauna Monitoring 2019-18</p> <p>GME Resources NiWest Nickel-Cobalt Project Level 1 Fauna Assessment 2018</p> <p>Artemis Resources Weerianna, Nickol River, Carlow Castle Tenements Targeted Northern Quoll & Ghost Bat Assessment 2018</p>
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SELECTED PROJECTS – JORDAN VOS

Fortescue Metals Group

Fortescue Valley | Detailed Flora and Vegetation Assessment
2018

Toro Energy

Centipede to Millipede | Level 2 Terrestrial Fauna Assessment
2015

Sheffield Resources

Thunderbird Project | Short Range Endemic Fauna Assessment
2014

Mount Gibson Mining

Mt Gibson Project | Targeted Malleefowl and Shield-backed Trapdoor Spider Assessment
2014

BHP Billiton Iron Ore

Marillana | Targeted Brush-tailed Mulgara Assessment
2014

BHP Billiton Iron Ore

Karijini | Targeted Ghost Bat Assessment
2014

Fortescue Metals Group

Mt Macleod & Stingray | Level 2 Terrestrial & Short Range Endemic Fauna Assessment
2013

Polaris/MRL

J4, J5 & Bungabbin East | Level 2 Terrestrial, Short Range Endemic & Subterranean Fauna Assessment
2013

Zenith Minerals

Mt Alexander | Level 2 Terrestrial Fauna Assessment
2012

Fortescue Metals Group

Anketell North | Level 2 Terrestrial Fauna Assessment
2011

Sinosteel Midwest

Blue Hills – Mungada East | Level 1 Terrestrial Fauna Assessment
2011

Artemis Resources

Radio Hill, Silica Hills, 47 Patch, Carlow Castle and Weerianna Tenements | Level 1 & Targeted Significant Fauna Assessment
2018

Citic Pacific

Cape Preston | Targeted Significant Fauna Assessment
2016

Toro Energy

Centipede to Millipede | Detailed Flora and Vegetation Assessment
2014

Lamboo Resources

McIntosh Project | Level 2 Terrestrial & Short Range Endemic Fauna Assessment
2014

BHP Billiton Iron Ore

Mudlark Project | Level 2 Terrestrial Fauna Assessment
2014

BHP Billiton Iron Ore

Ore Body 19 | Level 2 Terrestrial Fauna Assessment
2014

Fortescue Metals Group

Fig Tree Tenement | Level 2 Terrestrial Fauna Assessment
2014

Fortescue Metals Group

Kutayi | Level 2 Terrestrial & Short Range Endemic Fauna Assessment
2013

Fortescue Metals Group

Delphine | Level 2 Vertebrate Fauna Assessment
2012

Fortescue Metals Group/Ironbridge

North Star | Level 2 Vertebrate Fauna Assessment
2012-2011

Fortescue Metals Group

Central Pilbara Project | Targeted Significant Fauna Assessment
2011

Fortescue Metals Group

Christmas Creek Northern Tenements | Reconnaissance Flora and Vegetation Survey
2017

Sinosteel Midwest

Mungada East | Targeted Shield-backed Trapdoor Spider Assessment
2015

Fortescue Metals Group

Solomon Life of Mine | Leve 2 Terrestrial & Short Range Endemic Fauna Assessment
2014

Griffin Coal Mining Company

Griffin Coal Mine | Venomous Snake Relocation
2014

BHP Billiton Iron Ore

South Flank Project | Targeted Northern Quoll Assessment
2014

BHP Billiton Iron Ore

Ore Body 19, 31, Nth Wheelarra, Mesa Gap tenements | Short Range Endemic Fauna Assessment
2014

Fortescue Metals Group

Mt Macleod & Stingray | Targeted Northern Quoll Assessment
2013

Fortescue Metals Group/Ironbridge

North Star Access Corridor | Vertebrate Fauna Assessment (Level 1)
2013

Fortescue Metals Group

Eliwana & Flying Fish | Level 2 Vertebrate Fauna Assessment
2012

Fortescue Metals Group

Anketell South | Level 2 Terrestrial Fauna Assessment
2011

Fortescue Metals Group

Northstar Additional Areas | Targeted Northern Quoll Assessment
2011

SELECTED PROJECTS – JORDAN VOS

Hazelwood Resources

Cooke's Creek | Level 2 Terrestrial Fauna Assessment
2011

Fortescue Metals Group

Anketell Central | Level 2 Terrestrial Fauna Assessment
2011

Woodside Energy

James Price Point | Level 2 Terrestrial & Short Range Endemic Fauna Assessment
2011

Flinders Mines

Blacksmith tenement | Level 2 Terrestrial & Short Range Endemic Fauna Assessment
2011

Fortescue Metals Group

Central Pilbara Project | Level 2 Terrestrial Fauna Assessment
2011

Fortescue Metals Group

Firetail South East | Level 2 Terrestrial Fauna Assessment
2011

CHRIS SHAW

BOTANIST | ECOLOGIST



COMPETENCIES

Multivariate statistical and data analysis
Rehabilitation monitoring
Water monitoring
GIS mapping
Flora assessments
Forest pathology

TRAINING

Provide first aid
Construction white card
Driver & 4WD competency
Dieback green card
R and SPSS software
QGIS training
DNA sequencing
Technical writing
Plant disease diagnostics

SUMMARY

Chris worked in research between 2015 and 2020 and casually in the environmental consulting industry since 2017. Chris's expertise extends to the identification and the conservation of flora in Western Australia and has been working as a botanist for Spectrum Ecology since 2020. Chris has developed expertise in the collection and statistical analysis of environmental data sets, including community analyses, multivariate modelling, and distribution modelling. Chris has contributed to the research and management of plant disease in Western Australia, preparing management and communication documents.

EDUCATION

DOCTOR OF PHILOSOPHY
(ENVIRONMENTAL SCIENCE)
Murdoch University
2016 -

BACHELOR OF SCIENCE WITH
HONOURS
Murdoch University
2015

BACHELOR OF ENVIRONMENTAL
MANAGEMENT
Murdoch University
2014

EMPLOYMENT

BOTANIST
Spectrum Ecology
2020-Present

PHD CANDIDATE
Murdoch University
2016-2020

ENVIRONMENTAL SCIENTIST
Clark Lindbeck & Associates
2017-2018

CAREER HIGHLIGHTS

BHP WAIO
Rehabilitation monitoring
2020

Chris was a team member who conducted the on-ground rehabilitation monitoring at BHP WAIO's Northern Mines in 2020. Additionally, Chris was responsible for the rehabilitation reporting of the Northern, Central, and Eastern Pilbara mining regions.

Broome Shire
Detailed & targeted flora survey
2020

Chris conducted a detailed and targeted flora survey across five sites surrounding Broome in April 2020. Quadrats and transects were conducted to map vegetation, vegetation condition, and the location of Priority flora and Priority Ecological Communities.

Tungsten Mining
Mt Mulgine targeted flora survey
2020

Chris was a team member and helped undertake a targeted flora survey across Mt Mulgine in the Yalgoo IBRA region. The survey area has a high number and density of conservation significant flora.

Research
Plant microbe interactions
2016 to 2020

Chris combined eDNA sequencing and ecological models to better describe the interaction between plants and soil microbes. The research was conducted in natural and rehabilitated plant communities on the Geraldton Sandplains IBRA region.

Research
Phytophthora survey and distribution modelling
2018 to 2019

Chris mapped the presence of native and introduced plant pathogens to determine their distribution in natural vegetation in southwest Australia. Additionally, Chris modelled key soil and climate variables to assess their influence on the distribution of *Phytophthora*.

SELECTED PROJECTS – CHRIS SHAW

Strandline Resources Limited

Coburn Mineral Sands | Targeted flora survey
2020

Tungsten Mining

Mt Mulgine | Targeted & reconnaissance flora and vegetation assessment
2020

Department of Justice

Broome Custodial Facility | Detailed flora & Level 1 fauna survey
2020

BHP WAIO

Nimingarra – Shay Gap | Rehabilitation monitoring
2020

Research Collaboration

Banksia woodland: 30-year literature review
2020

Halls Creek Mining

Halls Creek Gold Mine | Water monitoring and environmental auditing
2017 - 2018

Murdoch University

Research | Functional plant trait modelling
2016

IB Operations

North Star | Targeted flora survey
2020

BHP WAIO

Port Hedland DMMA | Rehabilitation monitoring
2020

Shire of Broome

Broome Waste Facility | Detailed flora & Level 1 fauna survey
2020

BHP WAIO

BHP | Rehabilitation remote sensing data analysis and reporting
2020

Research Collaboration

Protea and Proteaceae farming global plant disease transmission
2019

Murdoch University

Research | Mineral sands rehabilitation monitoring and experiments
2017 - 2019

South Coast NRM

Phytophthora Dieback management review and weighted decision matrix
2015

Fortescue Metals Group

Chichester Hub | Rehabilitation remote sensing data analysis and reporting
2020

Shire of Broome

Broome Waste Facility | Priority flora & Bilby pre-clearance survey
2020

BHP WAIO

BHP | Moonscape rehabilitation data analysis and reporting
2020

Murdoch University

Research | Plant microbe interaction ecology
2020

Murdoch University

Research | Plant disease survey and environmental variable modelling
2019

Research Collaboration

South African plantation susceptibility to forest pathogens
2019

BHP Billiton/South 32

Boddington Bauxite Mine | Environmental vocational work, environmental monitoring and rehabilitation.
2014 - 2015

TIM HAMMER

BOTANIST



COMPETENCIES

Flora & vegetation surveys
Species identification
Plant morphology
Plant taxonomy
Herbarium practices
Conservation assessments
Data analysis & interpretation
Modelling
GIS

TRAINING

Provide first aid
Driver & 4WD competency

SUMMARY

Tim holds a PhD from the University of Western Australia in Botany and Plant Taxonomy as a Forrest Research Foundation Scholar. He has extensive experience with the flora of Western Australia and worked closely with the staff of the Western Australian Herbarium (DBCA) to develop species identification keys, describe new species and complete floral surveys throughout the state, including in the Pilbara, Mid-west Goldfields and South-west. He is a research associate at the Western Australian Herbarium and has been a visiting botanist at other Australian state herbaria. He has developed novel approaches to integrate geospatial modelling for use within plant taxonomy, which have informed taxonomic decisions and allowed for clear species delimitations within morphologically complex plant groups.

EDUCATION

DOCTOR OF PHILOSOPHY
(BOTANY)
The University of Western
Australia
2019

MASTER OF SCIENCE
(BOTANY)
Old Dominion University
2014

BACHELOR OF SCIENCE
(BOTANY)
Old Dominion University
2012

EMPLOYMENT

BOTANIST
Spectrum Ecology
2019-Present

POSTGRADUATE RESEARCHER
(BOTANY)
The University of Western
Australia
2015-2019

RESEARCH ASSISTANT
(BOTANY)
Old Dominion University
2012-2014

CAREER HIGHLIGHTS

Minjar Gold
Rehabilitation
monitoring and
targeted survey 2019

Evolution Mining
Rehabilitation
monitoring and
targeted survey 2019

Species Identification

PhD Research

Tim has been involved in various aspects of the Minjar Gold rehabilitation monitoring and targeted survey in 2019, which included surveys across rehabilitation and analogue sites, targeted searches for Threatened and Priority Flora, species identification, Landscape Function Analysis, data analysis, and reporting

Tim has been involved in various aspects of projects at Evolution Mining's Mungari Gold Operations for rehabilitation monitoring and for Threatened and Priority Flora targeted surveys in 2019; his tasks included surveys across rehabilitation and analogue sites, species identification, data analysis, and reporting.

Tim has identified plant specimens for numerous surveys in the Goldfields, Mid-west, Pilbara and South-west regions of Western Australia, as well as having extensive experience in plant identification and taxonomy during his tertiary education.

During his PhD, Tim completed several multidisciplinary research projects on the taxonomy and systematics of *Ptilotus* (mulla mulla), resulting numerous publications and the discovery of new genera and species.

SELECTED PROJECTS – TIM HAMMER

BHP WAIO Weeli Wolli PEC Detailed flora & vegetation survey 2020	Westgold Resources Ltd Nannine Mining Area Flora recon report 2020	Shire of Broome Broome Species IDs for detailed flora survey 2020
Fortescue Metals Group North Star Species distribution modelling 2020	Tungsten Mining Mount Mulgine Species distribution modelling & species IDs 2020	BHP WAIO Port Hedland DMMA rehabilitation monitoring & species IDs 2020
Murdoch University Murdoch Detailed flora and vegetation survey & species IDs 2020	Hanson Construction Gnangara Rehabilitation monitoring 2020	Tungsten Mining Mount Mulgine Species IDs for detailed flora survey 2019
Goldfields Power JV Parkeslon Solar Farm Species IDs 2019	Murdoch University Murdoch Flora recon survey & species IDs 2019	Evolution Mining Mungari Gold Operations Targeted survey & species distribution modelling 2019
Hanson Construction Gnangara & Gingin Rehabilitation monitoring & species IDs 2019	Barra Resources Mount Thirsty Targeted survey & species IDs 2019	Evolution Mining Mungari Gold Operations Rehabilitation Monitoring & species IDs 2019
Minjar Gold Southern Cross Operations Rehabilitation monitoring & species IDs 2019	Fortescue Metals Group Solomon Species distribution modelling 2019	The University of Western Australia PhD Research Taxonomy of <i>Ptilotus</i> (mulla mulla) 2015–2019
Western Australian Herbarium (DBCA) Research Misc. taxonomic research & field work throughout WA 2013–2020		