WHIM CREEK – 2021 VEGETATION MONITORING REPORT

Prepared for
Anax Metals Limited

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Whim Creek 2021 Vegetation Monitoring Report

Prepared for
Anax Metals Limited

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1 Introduction

Anax Metals Limited (Anax) the tenement holder of Whim Creek mining tenements, is required to undertake compliance vegetation monitoring in accordance with the Vegetation Monitoring Plan (VMP) (360 Environmental Pty Ltd 2020) which was developed as a requirement of the Environmental Protection Notice (EPN) (Ref No. DWERDG804/19).

The compliance vegetation monitoring was implemented and conducted by 360 Environmental Pty Ltd (360) in 2020. The VMP requires biannual monitoring of both the terrestrial and riparian vegetation; one following substantial rains (wet season) and one during the dry season.

Vicki Long and Associates (VLA) was commissioned by Anax to undertake the 2021 compliance vegetation monitoring according to the VMP, across 12 terrestrial and eight riparian sites at Whim Creek (Figure 1). This annual report for 2021 presents the results of the vegetation monitoring undertaken at Whim Creek in March 2020, October 2020, April 2021 and October 2021. Visual assessments (photos) are presented for April 2021 and October 2021.

2 Objectives and Scope

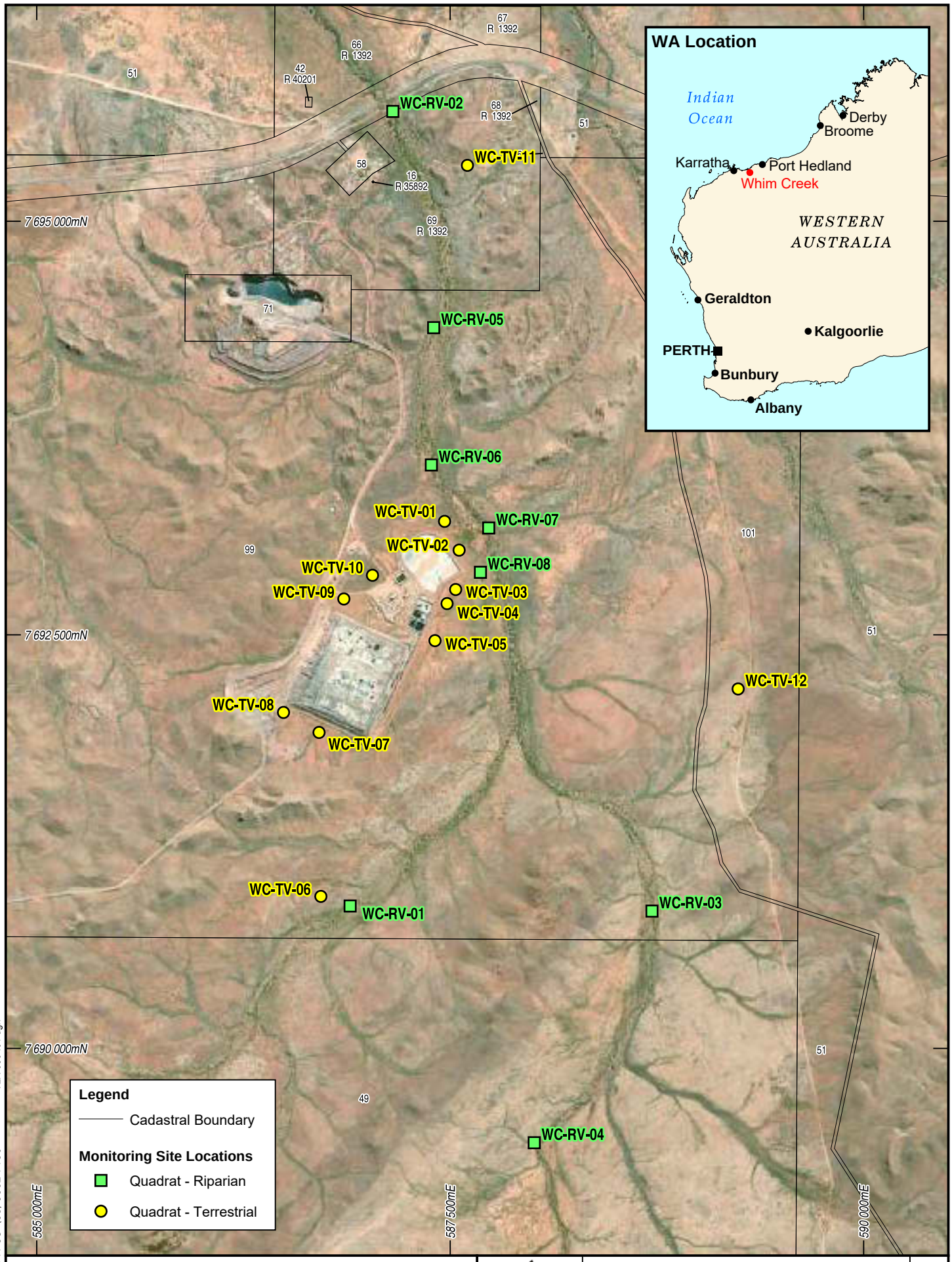
A VMP has been developed to understand and monitor the terrestrial and riparian vegetation on a spatial and temporal scale within the vicinity of the heap leach pads, process water ponds, the environmental pond, Balla Balla River and reference locations. The results of this monitoring will be used to assess the baseline vegetation health across the Whim Creek Site and provide an insight into any temporal changes.

The scope of works includes:

- Monitoring vegetation health at 12 terrestrial vegetation sites and eight riparian vegetation sites. Terrestrial sites are located near the existing heap leach pad, process water ponds, and environmental pond, while riparian sites are located in the Balla Balla River and /or in tributaries off the river.
- Assess the vegetation health in accordance with the VMP and the methods outlined in Section 3
- Report within 28 days of completing the monitoring event on the vegetation condition and conduct statistical analyses to determine sources of significant difference, if any.

Anax is required to report against its compliance with Requirement 37 of the EPN which states:

- Within 28 days from the day after the completion of each vegetation monitoring event, the Mining Tenement Holder must provide a written report to the CEO. This report must include as a minimum:
    - *37.1 results from all vegetation health assessments undertaken in implementation of the Approved VMP*
    - *37.2 photographic records from all vegetation monitoring undertaken at the specified monitoring points*
    - *37.3 as assessment of the monitoring data, including but not limited to, any deterioration in the presence and/or quality of the vegetation monitored.*


WA Location
Indian Ocean
Derby
Broome
Karratha
Port Hedland
Whim Creek
WESTERN AUSTRALIA
Geraldton
Kalgoorlie
PERTH
Bunbury
Albany
WC-RV-02
WC-TV-11
WC-RV-05
WC-RV-06
WC-TV-01
WC-RV-07
WC-TV-02
WC-TV-10
WC-RV-08
WC-TV-09
WC-TV-03
WC-TV-04
WC-TV-05
WC-TV-12
WC-TV-08
WC-TV-07
WC-TV-06
WC-RV-01
WC-RV-03
WC-RV-04
7 695 000mN
7 692 500mN
7 690 000mN
585 000mE
587 500mE
590 000mE
Legend
Cadastral Boundary
Monitoring Site Locations
Quadrat - Riparian
Quadrat - Terrestrial
0 200 400 600 800 1000m
SCALE 1 : 30 000 at A4 (MGA)
N
CADASTRAL SOURCE: Landgate, April 2021.
AERIAL PHOTOGRAPH SOURCE: ESRI, flown June 2020.
PINPOINT CARTOGRAPHICS (08) 9562 7136
VLA-080-f01.dgn
vla vicki long & associates
Date: 29 Apr 2021
Drawn: V. Long
Anax Metals Limited
VEGETATION MONITORING - APRIL 2021
WHIM CREEK
VEGETATION MONITORING SITE LOCATIONS
Figure 1

3 Existing Environment

3.1 Project Location

The monitoring sites are located approximately 100 km south-west of Port Hedland in the town of Whim Creek, in Western Australia's Pilbara Region. The sites are adjacent to the Balla Balla River, which is located on the southern side of the Yirrakulanna Hills and flows in a north-easterly direction before discharging into the Balla Balla Inlet and the Indian Ocean. The Balla Balla River near the Whim Creek operations is ephemeral, being dry in the summer months and inundated during seasonal rainfall and associated flooding events.

3.2 Climate

The closest Bureau of Meteorology (BoM) weather station that provides continuous reliable temperature and rainfall data to the Survey Area is located at Roebourne Aero (Site Number: 004090) (Bureau of Meteorology, 2021), which is located approximately 70 km west of the Whim Creek monitoring sites.

The wet season monitoring survey was undertaken between 6th and 7th April 2021 and the post dry season monitoring between the 26th and 28th October 2021.

In the three-month period prior to the wet season survey being undertaken, a total of 132 mm of rainfall had been recorded for the Whim Creek area (BOM 2021) which is below average for that time period (170 mm) (Figure 2). The 81 mm of rainfall recorded in December 2020 was five times the average rainfall for that month and was associated with a tropical low from the north-west. Above average rainfall in early February 2021 (97.8 mm) was associated with a tropical low which developed in the Kimberley region near the Western Australian / Northern Territory border.

A large rainfall event in May 2021 (225mm) occurred following the April survey. In the three month period prior to the dry season survey, virtually no rainfall was received in the area.

A summary of climatic data is presented in Figure 2.

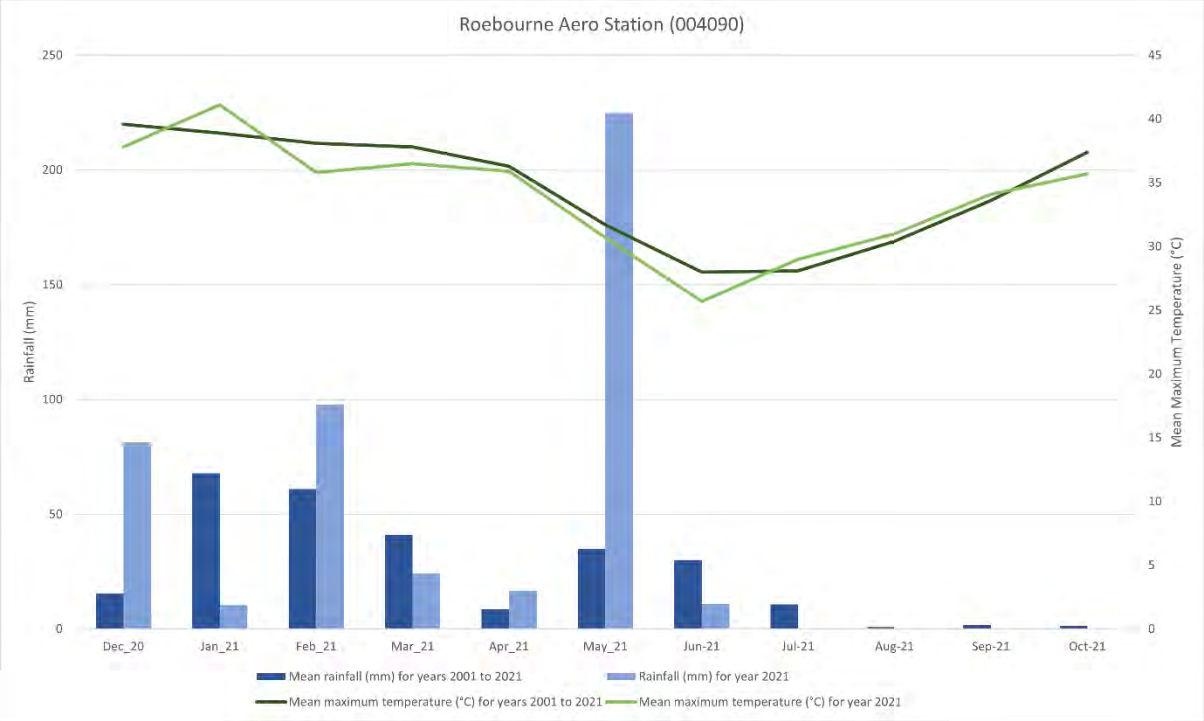


Figure 2. Maximum Temperature and Rainfall Data (2020/2021) and long term means for Roebourne Aero (Stn ID 004090) (BOM 2021)

Monitoring was undertaken by Principal Botanist, Vicki Long (FB 62000120) of VLA twice within the year. Post wet season monitoring was undertaken on the 6th and 7th April 2021 and post dry season monitoring between the 26th and 28th October 2021. Monitoring on both occasions was carried out in accordance with the methods described in the VMP developed by 360 Environmental Pty Ltd (2020), to assess the potential changes in vegetation health on a temporal and spatial scale. Vicki has had 36 years of flora and vegetation baseline monitoring and condition assessment in the Pilbara and has worked on the Whim Creek site (as Astron Environmental Services) since 2000.

4 Methodology

4.1 Monitoring Design

360 Environmental Pty Ltd developed a vegetation monitoring program in 2020 based on parameters and methods to assess the potential changes in vegetation health on a temporal and spatial scale. The number of monitoring parameters were selected to consider site specific conditions and the different types of vegetation present (ie. terrestrial and riparian vegetation).

The frequency of the monitoring program was set as biannual to capture seasonal variations in available water and vegetation condition. Currently monitoring is scheduled to occur post wet season (ie. between March and June) and post dry season (between Aug and November).

Twenty monitoring sites were established by 360 Environmental Pty Ltd in 2020. Twelve of these sites are located within terrestrial vegetation, where 50m x 50m quadrats have been demarcated. Of these twelve quadrats, nine have been established within the potential impact area (Impact sites) and three outside the area (Reference sites). The remaining eight sites (each with 10 trees) are located within riparian vegetation; five within the potential impact area (Impact sites) and three outside the area (Reference sites). The locations of these quadrats are summarised in Table 1 and shown on Figure 1.

Table 1. Monitoring Site Locations

Monitoring Site	Vegetation Type	Status	Latitude	Longitude	Easting	Northing
WC-TV-01	Terrestrial	Impact	-20.85938080	117.84078740	587466	7693186
WC-TV-02	Terrestrial	Impact	-20.86095480	117.84164280	587554	7693012
WC-TV-03	Terrestrial	Impact	-20.86310180	117.84145310	587533	7692774
WC-TV-04	Terrestrial	Impact	-20.86387240	117.84095650	587481	7692689
WC-TV-05	Terrestrial	Impact	-20.86590500	117.84026870	587408	7692465
WC-TV-06	Terrestrial	Reference	-20.87989890	117.83370710	586718	7690919
WC-TV-07	Terrestrial	Impact	-20.87095070	117.83355660	586707	7691910
WC-TV-08	Terrestrial	Impact	-20.86986910	117.83148160	586492	7692031
WC-TV-09	Terrestrial	Impact	-20.86365250	117.83496180	586857	7692717
WC-TV-10	Terrestrial	Impact	-20.86241480	117.83724530	587030	7692860
WC-TV-11	Terrestrial	Reference	-20.83993450	117.84200870	587604	7695338
WC-TV-12	Terrestrial	Reference	-20.86845280	117.85789810	589241	7692173
WC-RV-01	Riparian	Reference	-20.88042089	117.83541597	586895	7690861
WC-RV-02	Riparian	Impact	-20.83701470	117.83765220	587153	7695664
WC-RV-03	Riparian	Reference	-20.88061440	117.85295910	588720	7690830
WC-RV-04	Riparian	Reference	-20.89329320	117.84618490	588008	7689430
WC-RV-05	Riparian	Impact	-20.84881160	117.84009260	587400	7694357
WC-RV-06	Riparian	Impact	-20.85630650	117.84000510	587386	7693527

Monitoring Site	Vegetation Type	Status	Latitude	Longitude	Easting	Northing
WC-RV-07	Riparian	Impact	-20.85973070	117.84336001	587733	7693146
WC-RV-08	Riparian	Impact	-20.86215320	117.84289460	587684	7692878

4.2 Terrestrial Vegetation

A total of 12 representative quadrats were established by 360 Environmental in 2020; nine impact sites and three reference sites. Of the nine 50 m x 50 m impact sites, three sites are located near the heap leach pads, three near the process water ponds and three near the environmental pond. An additional three reference (control) monitoring quadrats (50 x 50 m) were installed to allow for temporal and spatial comparisons to be drawn.

4.2.1 Vegetation Composition

Within each terrestrial vegetation quadrat, the following were recorded:

- Individual species richness and abundance
- Species height and percent cover
- Vegetation description – vegetation units were described according to Aplin's (1979) modification of the vegetation classification system of Specht (1970) (Table A.1, Appendix A) and the National Vegetation Information System Level 5 (Department of Agriculture, Water and the Environment, 2020a). At this level vegetation is described to 'association' where up to three dominant genera for each of the upper, mid and ground strata are categorised based on dominant growth form, cover and height
- Photograph from the north-western corner of the quadrat looking towards the south-eastern corner.

4.2.2 Vegetation Condition

Vegetation condition (health) was assessed using the vegetation condition scale adapted from Keighery (1994) and Trudgen (1988) (Table A.2, Appendix A) as per EPA Technical Guidelines (2016) for the Eremaen and Northern Botanical Provinces.

4.2.3 Weed Species and Cover

All weed species present were recorded, with weed cover being assessed as a percentage of total foliar cover within each quadrat.

4.2.4 Erosion

Key erosion features within each quadrat were assessed as per Tongway and Hindley (2004), with severity of erosion being classified in accordance with Table B.1 (Appendix B).

4.2.5 Other pressures

Any other pressures (grazing, fire, flooding, offroad vehicle activity) potentially impacting the sites were recorded.

4.3 Riparian Vegetation

A total of eight riparian sites (five Impact sites – located downstream from mining operations and three Reference sites – located upstream of mining operations) were established by 360 Environmental (2020) to determine the health of riparian vegetation.

At each of the eight riparian vegetation sites, ten phreatophytic trees (80 trees in total), were qualitatively assessed using an adaptation of methods described by Schomaker *et al* (2007) and Souter (2010) to determine changes in key features used to identify tree stress.

The following attributes of each tree (as per Schomaker *et al* 2007) were recorded:

- **Crown Density**

Definition - Crown density is the amount of crown stem, branches, twigs, shoots, buds, foliage, and reproductive structures that block light penetration through the crown. Dead branches and dead tops are part of the crown. Live and dead branches below the live crown base are excluded. Broken or missing tops are visually reconstructed when forming this crown outline by comparing the tops of adjacent healthy trees of the same species and stem diameter

Intended Use - is to estimate the percentage of crown volume that contains biomass. Trees with below average crown density are expected to have reduced growth compared to trees with full, symmetrical crowns.

- **Foliage Transparency**

Definition - Foliage transparency is the amount of skylight visible through microholes in the live portion of the crown, i.e., where foliage or remnants of foliage occur. Recently defoliated branches are included in the foliage transparency measurements. Macroholes are excluded unless they are the result of recent defoliation. Dieback and dead branches are always excluded from the estimate. Foliage transparency is different from crown density because it emphasizes foliage and ignores stems, branches, fruits, and holes in the crown

Intended Use - is a measurement of defoliation or stress. The amount of foliage in a crown is related to tree growth. A tree with more foliage is expected to have a higher growth potential, vigour, survivability, and reproductive potential than a tree of the same species with less foliage. High foliage transparency indicates a loss of vigour and growth potential. Usually, serious effects are not expected until a tree loses half of its foliage or unless significant defoliation persists over multiple seasons. The average foliage transparency of healthy trees tends to be species-specific.

- **Crown Dieback**

Definition - Crown dieback is the recent mortality of branches with fine twigs that begins at the terminal portion of a branch and proceeds towards the trunk. Dieback is considered only when it occurs in the upper and outer portions of the tree. When whole branches are dead in the upper crown, without obvious signs of damage such as breaks or animal injury, assume that the branches died from the terminal portion of the branch. Dead branches in the lower live crown are not considered as part of crown dieback unless there is continuous dieback from the upper and outer crown down to those branches

Intended Use - estimates the severity of recent stresses on trees. Increased dieback reduces growth. The measurement serves as an early indicator of loss of vigour and growth potential in response to stresses or damage. High crown dieback indicates defoliating agents or other stressors such as drought, root rots, canker diseases, and root mortality due to deep frosts. However, some crown dieback results from normal tree processes, such as excessive seed production. Thus, minor crown dieback probably does not indicate an abnormal condition.

The measurement scale used (Schomaker et al. 2007) and the visual assessment chart for crown density and foliage transparency are provided in Table C.1 and Figure C.1, Appendix C.

Additional qualitative tree health was visually assessed for each phreatophytic tree according to an adaptation of Souter et al. (2010). Table D.1, Appendix D summarises the visual health score of key features.

5 Statistical Analyses

The main aim of the statistical analysis of the riparian and terrestrial vegetation data was to compare the inter-annual changes in measured variables between the Impact sites and the Reference sites. The focus of the monitoring is to differentiate between natural fluctuations in vegetation parameters from those potentially arising from mining activity. Measuring changes within individual plots does not achieve this, and plots have been grouped into Impact and Reference categories for the analyses.

The measured variables were either continuous or categorical. For each continuous variable, the value of the 2020 data in each season was subtracted from the 2021 value for the corresponding season to calculate the change in that variable between years. Continuous variables included crown density, foliage transparency, crown dieback and total health score in the riparian zone, and species richness and the sum of foliage cover in the terrestrial zone.

Categorical variables included reproduction density, branch tip dieback extent, the presence of mistletoe, the extent of leaf chlorosis and the bark condition. For the riparian sites data, only observations for *Eucalyptus victrix* were used for analysis as no *Corymbia opaca* trees have been recorded for the Reference sites.

T-tests with a permutation step to produce a normal-distributed null population were used to check for statistically different changes in the continuous variables. The permutation step reduces the chances of false positives (Type 1 error) when sample sizes are small (i.e. $n < 30$) and/or the sampling design is unbalanced (i.e. there are many more samples in some categories than others). For categorical data, chi-squared tests were used to check for statistically significant differences in the in the size of categories between the treatment (Impact and Reference) zones. A significance level of $p = 0.05$ was set for all tests and were conducted using the "infer" (Bray et al. 2021) and "dplyr" (Wickham et al. 2021) packages in the R language (version 4.1.2; R Core Team, 2021). Graphs of the results were generated using ggplot2 (Wickham, 2016).

6 Results

6.1 Terrestrial Vegetation

The general health of vegetation recorded in all quadrats during the April 2021 survey was very healthy with good cover and high species diversity. There was no detectable difference in the health of vegetation, nor in individual species, between potential Impact and Reference sites. Photos were compared to the wet season March 2020 report and no decline in vegetation health was obvious, nor were there any indicators in the field of stress or poor health.

In the October survey, vegetation in all the terrestrial quadrats was dry as was expected given there was virtually no rainfall in the three months preceding the survey. Flora was either dormant or largely defoliated and the majority of annual species had senesced, resulting in a lower species cover and diversity (59 species) than that recorded in the April survey (91 species). There was no apparent difference in health of vegetation between the Impact sites and the Reference sites.

Table 2. summarises the results for the terrestrial quadrats for the 2021 surveys.

P-value tables for continuous terrestrial vegetation variables are provided in Appendix E.

Table 2. Summary of Quadrat Results

Quadrat, Type[1] and Location	Survey	Condition[2]	% Weeds	Erosion[3]	Cattle	Comment
WC-TV-01(1) – located approximately 100m north of environmental ponds and operations at Whim Creek	Apr '21	Very Good	Buffel grass (**Cenchrus ciliaris)* <2%	Nil	Minor	Cleared track to a groundwater bore was installed post March 2020 and pre October 2020 as noted in the 360 Environmental November 2020 report. Buffel grass is mainly associated with this track along edge of quadrat.
	Oct '21	Excellent	Nil	Nil	No recent evidence of cattle	Track runs along western edge of quadrat not through quadrat as stated by 360 Environmental.
WC-TV-02(I) - located approximately 60 m northwest from the environmental	Apr '21	Very Good	Buffel grass (**Cenchrus ciliaris)* <2%	Sheet erosion insignificant	Minor	Very minor sheet erosion as this quadrat is on the outer river floodplain. Buffel grass only under shade tree.Priority flora present.

Quadrat, Type[1] and Location	Survey	Condition[2]	% Weeds	Erosion[3]	Cattle	Comment
ponds and operations at Whim Creek	Oct '21	QUADRAT NO LONGER EXISTS. IT HAS BEEN DESTROYED BY THE CONSTRUCTION OF A TRACK INTO THE BORROW PIT AS WELL AS THE BORROW PIT ITSELF.				
WC-TV-03(I) - located approximately 80m southeast from the evaporation ponds at Whim Creek	Apr '21	Very Good	0%	Nil	Minor	A minor vehicle track runs through quadrat
	Oct '21	Excellent	0%	Nil	Nil	A minor vehicle track runs through quadrat. The presence of the aquatic herb *Marseila hirsut*a indicates that water is retained here. It has not been recorded in previous monitoring. Water retention may be natural or due to changed landform (bund wall) – which has been there a long time now
WC-TV-04(I) - located approximately 85 m south from the evaporation ponds at Whim Creek	Apr '21	Very Good	0%	Nil	Moderate	Distinct cattle track runs through quadrat
	Oct '21	Excellent	0%	Nil		Two minor tracks in northern portion of quadrat – no weeds to date
WC-TV-05(I) – located approximately 105 m southeast from process ponds at Whim Creek	Apr '21	Very Good	0%	Sheet erosion insignificant	Minor	Very minor disturbances. Priority flora present.
	Oct '21	Excellent	0%	Nil	Nil	P species *Heliotropium muticum* present in quadrat

Quadrat, Type[1] and Location	Survey	Condition[2]	% Weeds	Erosion[3]	Cattle	Comment
WC-TV-06(R) located approximately 1 km south from the heap leach pads and operations at Whim Creek	Apr '21	Very Good	0%	Nil	Minor	This quadrat was established with a track through NW corner of quadrat – the NW peg was moved this visit to avoid that disturbance as it is a reference quadrat.
	Oct '21	Excellent	0%	Nil	Minor – one cattle track diagonally through south-western corner but not recent	Reference quadrat that doesn't really match any of the Impact quadrats.
WC-TV-07(I) - located approximately 100 m south from the heap leach pads and operations at Whim Creek	Apr '21	Good, but revegetating	0%	Nil	Nil	Rehabilitation site – ripped, compact, rubble – site suitable for monitoring revegetation progress but comparison with other climax vegetation quadrats should be treated with caution. Revegetation progressing
	Oct '21	Good	0%	Nil	Nil	The quadrat has been placed in an area of low vegetation cover and does not reflect the cover over the entire rehabilitated area. As it is a rehabilitated site, any negative impacts from the leach pad may be confounded. There is not a suitable Reference for this quadrat.
WC-TV-08(I) - located approximately 60 m south from the heap leach pads	Apr '21	Good, but revegetating	0%	Nil	Nil	Rehabilitation site – ripped, compact, rubble – site suitable for monitoring revegetation progress but comparison with other climax

Quadrat, Type[1] and Location	Survey	Condition[2]	% Weeds	Erosion[3]	Cattle	Comment
and operations at Whim Creek						vegetation quadrats should be treated with caution. Revegetation progressing
	Oct '21	Excellent	0%	Nil	Nil	As it is a rehabilitated site, any negative results may be confounded. There is not a suitable Reference for this quadrat.
WC-TV-09(I) - approximately 140 m north from the heap leach pads and operations at Whim Creek	Apr '21	Very Good	0%	Nil	Nil	This is a pindan sand site, consequently has very high species diversity, different species. Comparison with other quadrats should be treated with caution. *Acacia arida* described as a dominant low shrub previously not recorded and was potentially a mistaken identification.
	Oct '21	Excellent	0%	Nil	Nil	P species *Heliotropium muticum* present in quadrat. There is no suitable Reference quadrat for this site.
WC-TV-10(I) - located approximately 150 m north from the processing plant and operations at Whim Creek	Apr '21	Very Good	1%	Nil	Nil	Vehicle tracks border two sides of this quadrat. Although **C. ciliaris* occurs along the tracks, there is <1% in quadrat itself.
	Oct '21	Very Good	<1%	Nil	Nil	Although **C. ciliaris* occurs along the tracks, there is <1% in quadrat
WC-TV-11(R) - located approximately 2.2 km north from	Apr '21	Poor	0%	Slight	Nil	This is the site of the old Whim Creek bottle dump. At least 50% of the quadrat is covered with broken bottles –

Quadrat, Type[1] and Location	Survey	Condition[2]	% Weeds	Erosion[3]	Cattle	Comment
evaporation ponds and operations at Whim Creek						indicating major disturbance in the past and current waste legacy. This quadrat has a totally different grass cover and is not suitable as a reference site. It is also a safety hazard.
WC-TV-12(R) - located approximately 2.05 km east from the heap leach pads and operations at Whim Creek	Apr '21	Very Good	Buffel grass (**Cenchrus ciliaris)* <2%	Nil	Nil	The quadrat is on silty soil with relatively dense stone mantle. It has been fire burnt around 5 years ago and has a well-used dirt road within 10 m which has both **Cenchrus ciliaris* and **Aerva javanica* bordering it. These weeds are creeping into the quadrat. Priority flora present. It does not match any Impact quadrat.
	Oct '21	Very Good	Kapok (**Aerva javanica*) <2% Buffel grass (**Cenchrus ciliaris)* <2%	Nil	Nil	P species *Heliotropium muticum* present in quadrat.

[1]Type I = Potential Impact, R = Reference; [2].EPA (2016) [3] Tongway and Hindley (2004)

6.1.1 Vegetation Condition

Vegetation condition during the April 2021 survey, as assessed against the scale recommended by EPA (2016), ranged from 'Very Good' for nine sites, 'Good' for two sites and 'Poor' for one site. In the October 2021 survey only 10 sites were monitored with seven sites being classified as 'Excellent', two as 'Very Good' and one site as 'Good'. These sites are identified and explained in Table 2.

In the April 2021 survey, **Cenchrus ciliaris* (buffel grass) was only present in three quadrats at a cover of less than 2%, whilst **Aerva javanica* was present in one quadrat at <1% cover. In the October 2021 survey, **C. ciliaris* was only recorded in two quadrats at a cover of less than 2% and **A. javanica* was present in one quadrat at <1% cover. The low occurrence of buffel grass is unusual for an area where

cattle graze and its presence was associated with tracks or with shady areas which are frequented by cattle.

6.1.2 Vegetation Cover

Large changes in the sum of foliage cover were observed in the terrestrial sites between 2020 and 2021. The decrease in total cover values ranged from 13 to 80% between wet seasons and from 25% to 98% between dry seasons. This is most likely due to a change in observers rather than an actual decline in vegetation cover. The photographic evidence indicates no significant changes between 2020 and 2021 which would support this assumption. No significant difference was found between treatments for either the wet or dry season (Figure 3 and Figure 4), although the decrease appears lower for the reference treatment in the dry season (Figure 3), but the difference was not statistically significant.

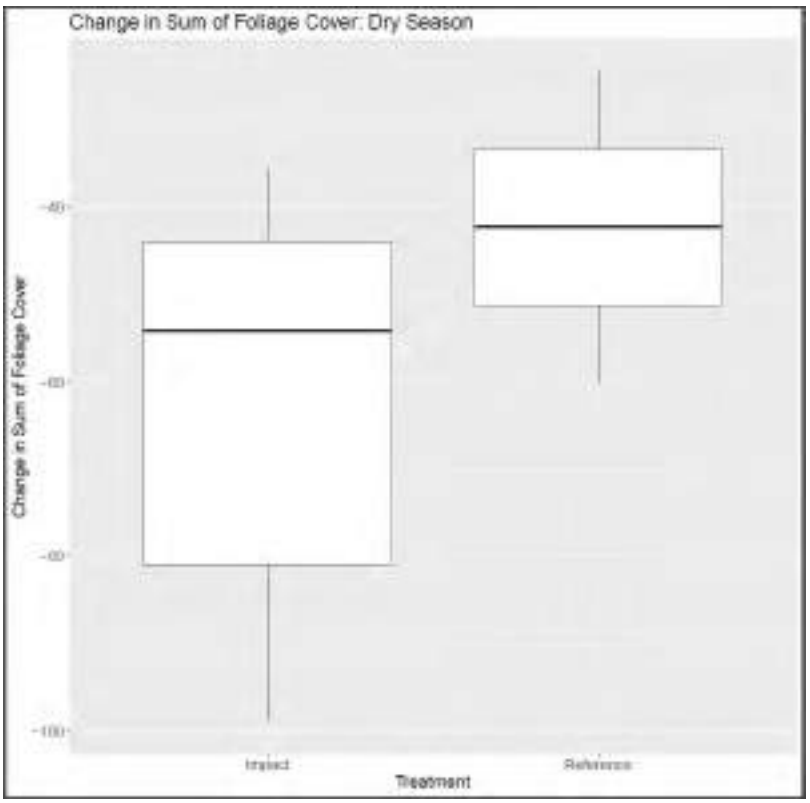


Figure 3. Change in Sum Foliage Cover between the Impact and Reference Sites for the Dry Seasons of 2020 and 2021.

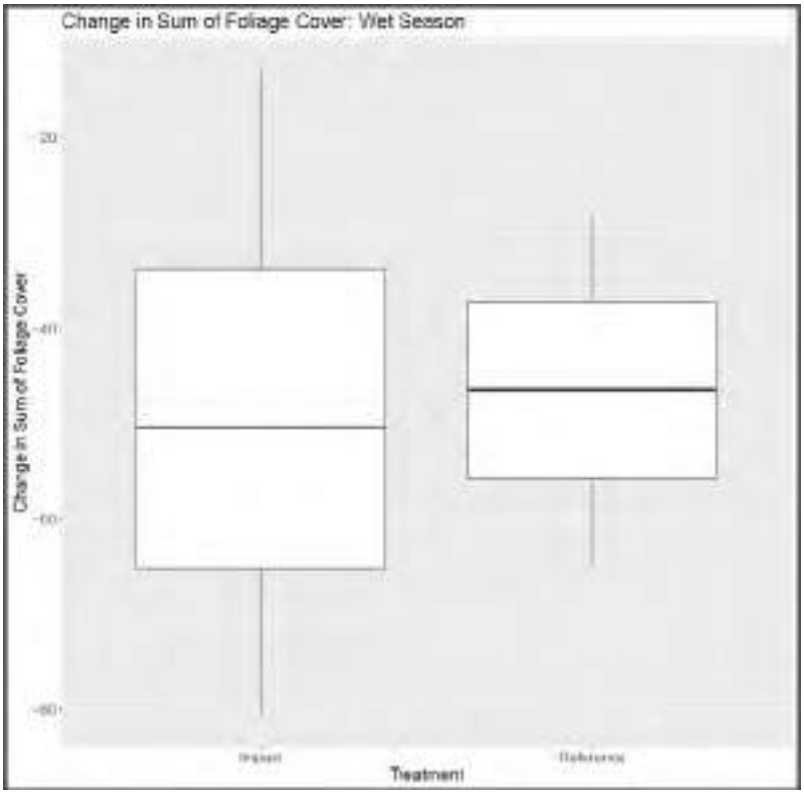


Figure 4. Change in Sum Foliage Cover between the Impact and Reference Sites for the Wet Seasons of 2020 and 2021.

6.1.3 Vegetation Descriptions

Descriptions for each of the terrestrial vegetation quadrats are summarised in Appendix F.

Some vegetation descriptions for quadrats varied between 2020 and 2021, again most likely due to different observers rather than a sudden lack or addition of key species. In most cases this was due to differences in estimating the foliar cover and dominance of species. The hummock grassland in most quadrats described in 2020 was described as "closed" which indicates the cover was 70-100%. This is rare in the Pilbara. Differences in recorded foliar cover are discussed in 6.1.2 above. In other cases, it would appear some mistaken species identifications were made in the 2020 surveys.

6.1.4 Species Richness

In April 2021, 91 vascular flora species were recorded within the terrestrial quadrats compared with 59 species being recorded in the post dry season, October 2021 survey. Lists of species recorded in both the April 2021 and October 2021 surveys area provided in Appendix G.

Statistical analyses showed that species richness increased in both years (2020 and 2021) for both the Impact and Reference treatments between both seasons (Figure 5 and Figure 6) and although the boxplot indicates a higher increase in the Reference treatment between wet seasons (Figure 6), this was not statistically significant. The low number of Reference sites (n = 3) may make it difficult to detect any real variation between treatments.

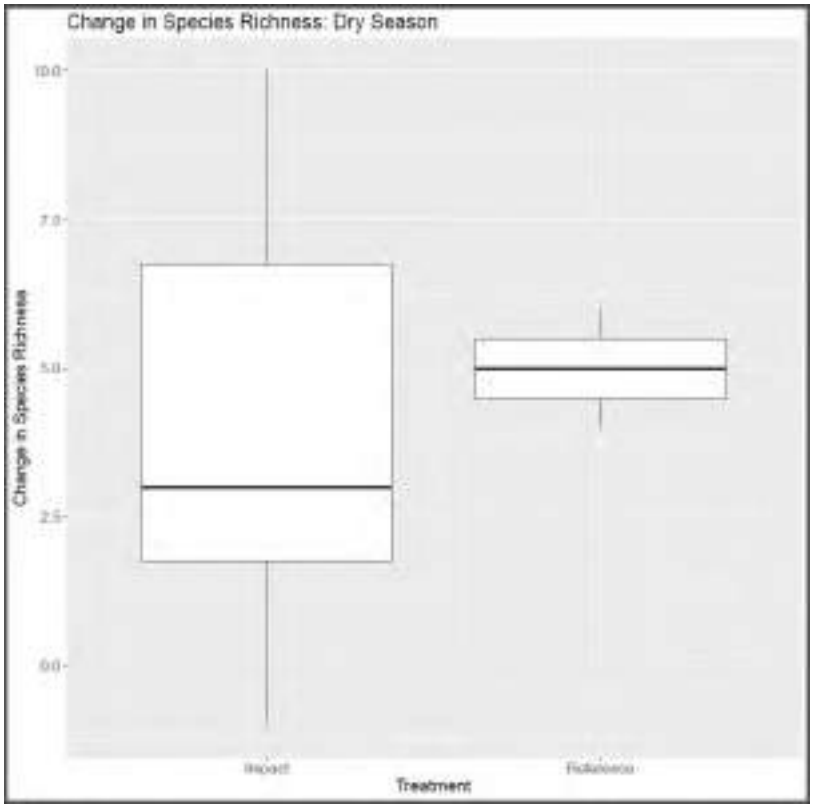


Figure 5. Changes in Species Richness (2020 and 2021) between the Impact and Reference Sites for the Dry Seasons

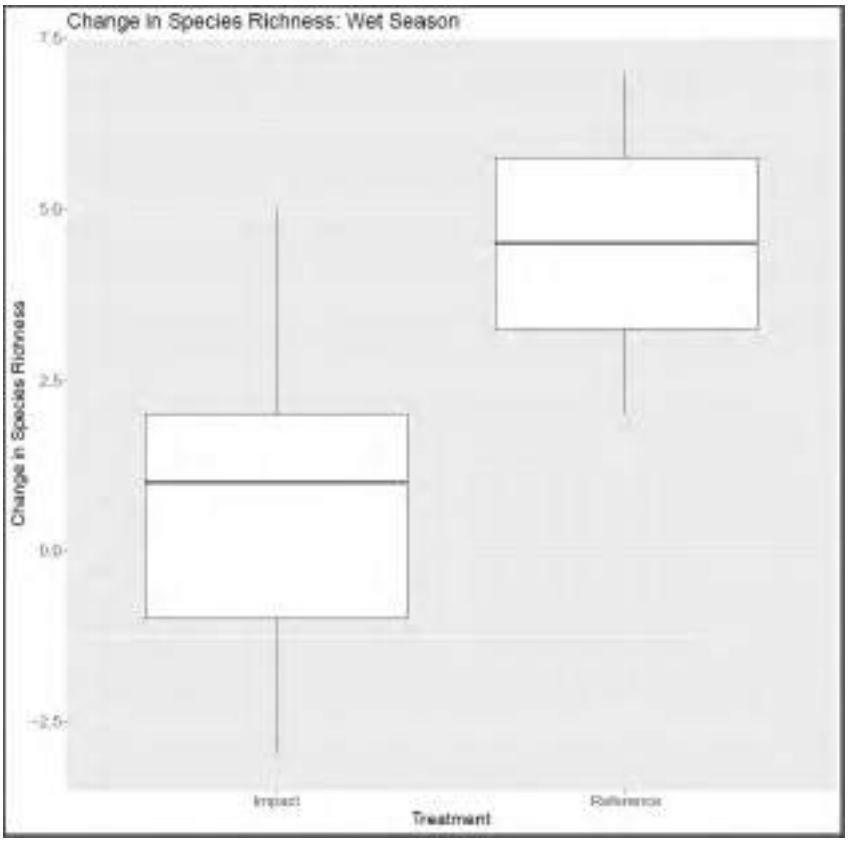


Figure 6. Changes in Species Richness between the Impact and Reference Sites for the Wet Seasons (2020 – 2021)

6.1.5 Erosion

Erosion was scored as insignificant in all quadrats during both surveys. Very minor sheet erosion from the heavy December 2020 and May 2021 rains was evident but was considered normal following rainfall events. Cattle tracks within quadrats were minor and at this stage have not caused erosion.

6.1.6 Cattle

The impact of cattle within the quadrats is minor, with some evidence of tracks and light grazing. As most quadrats are located outside the shaded areas and are dominated by spinifex, they do not provide favourable conditions for grazing or congregating cattle. These tracks may erode over time, but this is unrelated to, and not the responsibility of, the Whim Creek operations.

6.1.7 Other Issues

WC-TV-02

Site WC-TV-02 (I) could not be monitored during the October 2021 survey as the quadrat no longer exists. A wide track into the new borrow pit, as well as the borrow pit itself, now occurs where the quadrat was previously located. (see Photos, Appendix H)

WC-TV-11

The field botanist and co-author of this report considers the location of reference quadrat (WC-TV-11 (R)) as noted in the April 2021 survey, to be inappropriate and an alternative location should be sought. This quadrat is located on the site of an Old Whim Creek bottle dump (Plates 1 and 2), with at least 50% of the quadrat being covered with broken bottles. This site has also been subjected to a major historic disturbance. Additionally, the dominant grass cover species in this quadrat do not reflect those recorded in the Impact sites, hence it is not a good comparison site and should not be used as a Reference site. This site was omitted from the October 2021 survey.

Plate 1 and Plate 2. WC-TV-11 Quadrat showing the Old Whim Creek bottle dump

WC-TV-07 and WC-TV-08

Two 'potential impact' quadrats (WC-TV-07 and WC-TV-08) have been established to monitor impact from nearby heap leach pads, however, these quadrats have been located on an old, rehabilitated site, which is still progressing towards climax vegetation. The rehabilitated soils contain a significant amount of rubble and consequently house different colonising species to those found in the

surrounding area. Additionally, they have a lower foliar cover, when compared with the other 'potential impact' and 'reference' quadrats. It would be difficult to determine whether any potential impacts observed at these sites are a result of nearby heap leach activity or just a result of the ongoing rehabilitation process. Comparisons of data obtained from these quadrats with other monitoring quadrats, should be treated with caution. In addition, it is not possible for these two quadrats to be compared to a Reference site.

The fact that these two quadrats are located on a rehabilitated site (Photos Appendix H) does not appear to have been noted in previous reports. Some consideration should be given to relocating these two quadrats to sites which better represent the area down gradient of the heap leach pads.

Inadequate Reference quadrats and Reference quadrats located in unsuitable positions.

The number and location of the Reference quadrats is inadequate to provide valid statistical analyses or enable informative qualitative assessments to be undertaken.

Reference quadrats need to reflect the same landform and vegetation type found in the Impact quadrats. Quadrat WC-TV-11 has been removed for the reasons explained above, leaving only WC-TV-06 and WC-TV-12 as Reference sites.

WC-TV-06 is on a low, stony rise which tapers to a tributary of the Balla Balla river. The quadrat is on the higher part of the rise which has a dense, stony mantle and areas of shale caprock. This site does not match any of the Impact quadrats which are located predominantly on the lower part of the river flood plain with red alluvial silts, with a light or sparse stony mantle. Similarly, WC-TV-12 is on a low, stony hill slope and not associated with floodplain habitat at all.

Impact quadrats with no comparable Reference sites

Impact quadrat WC-TV-09 is located on a small area of red pindan sand and is quite different to the Impact quadrats on the alluvial silts of the river flood plain. There is no Reference quadrat to match this. It is a unique site and not comparable to any of the other Impact or Reference quadrats. Additionally, *Acacia arida* was in the original vegetation description for this quadrat, however there was no *Acacia arida* recorded in this quadrat during the 2021 surveys.

6.1.8 Priority Species

Heliotropium muticum, a Priority 3 species, is a very small, woody perennial herb (to 30 cm) (Plate 3) which has been well recorded in the general vicinity of, and within, the monitoring quadrats.

Plate 3. *Heliotropium muticum* (P3) species found in several monitoring quadrats.

Table 3 summarises the locations at which it was recorded during the surveys, together with the number of plants found at each location.

Table 3. Location of *Heliotropium muticum* (P3) plants recorded during the April 2021 and October 2021 monitoring surveys.

Quadrat	GPS Co-ordinates (UTM)	No. of Plants recorded
WC-TV-02 (I) – April 2021	587565E 7692889N	5 plants within 10m
	587579E 7692969N	3 plants
WC-TV-02 (I)October 2021	QUADRAT DESTROYED DURING CONSTRUCTION OF TRACK AND BORROW PIT	
WC-TV-05(I) – April 2021 / October 2021	587430E 7692429N	5 plants
	587438E 7692454N	3 plants
	587432E 7692429N	5 plants
	587438E 7692454N	3 plants
	587432E 7692429N	5 plants
WC-TV-09(I) – October 2021	586863E 7692716N	1 plant
WC-TV-12 (R) – April 2021	589284E 7692152N	2 plants
	589263E 7692149	5 plants
	589253E 7692144N	1 plant
WC-TV-12(R) – October 2021	589284E 7692152N	2 plants
	589263E 7692149	5 plants
	589253E 7692144N	1 plant
	589290E 7692161N	1 plant

6.2 Riparian Vegetation

Trees within all the riparian vegetation sites appeared to be healthy. New foliage, which was abundant but not mature, was evident on trees at most sites in October 2021, indicating trees are in good condition and are not impacted by external factors. There was no discernible difference in health between the Impact and Reference sites. One site WC-RV-08 will need to continue to be monitored as deep borrowing has occurred either side of the shallow drainage line which has now been truncated

by the borrow pit walls. Leaves on the trees within this site were dust covered, and this site showed little evidence of new foliage.

6.2.1 Tree Health

The tree health parameters in the riparian zone only showed significant differences between treatments for bark condition in 2020 and for branch tip dieback in 2021. By 2021, there was no significant difference for bark condition between treatments. P-value tables for continuous and categorical variables for riparian vegetation are provided in Appendix E.

Differences between treatments for crown dieback and foliage transparency can be observed (Figure 7 and Figure 8), but these are only significant at the less conservative level of 0.1.

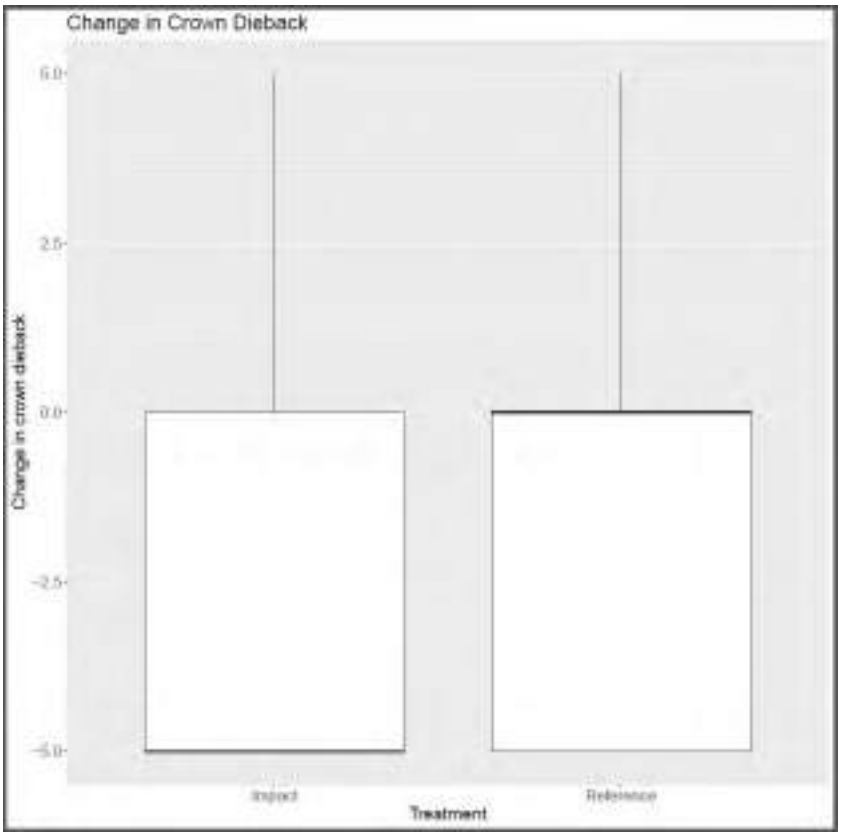


Figure 7. Changes in Crown Dieback for both the Impact and Reference Treatments (2020 – 2021).

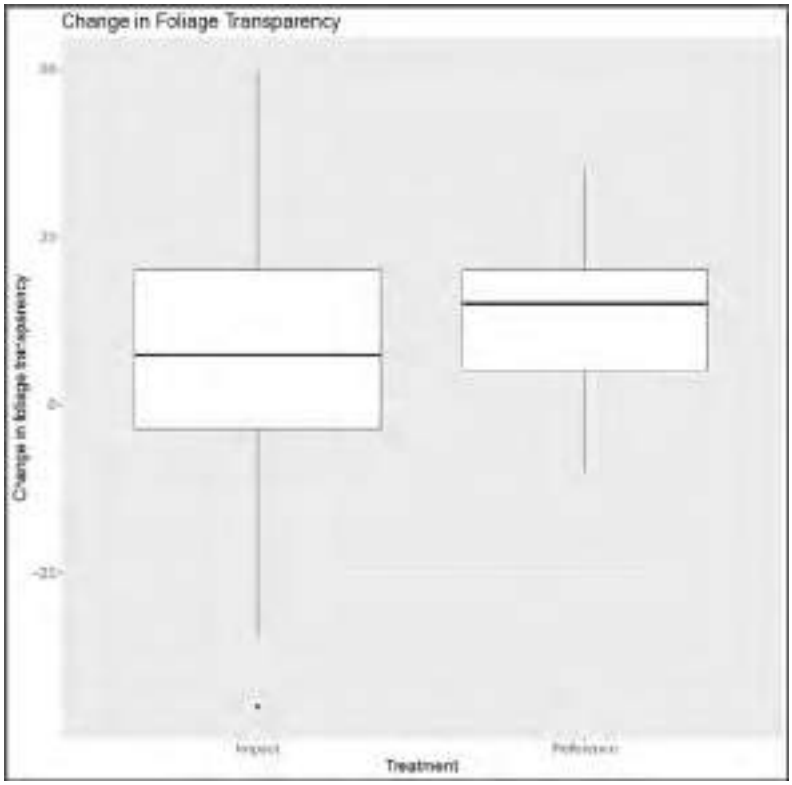


Figure 8. Change in Foliage Transparency for both Treatments (2020-2021)

For the categorical variables; reproduction ($p < 0.001$), bark condition ($p < 0.05$), chlorotic factor ($p < 0.001$) and branch tip dieback ($p < 0.001$), significant changes were recorded between years for both treatments, but any changes were common to both areas as the only differences between treatments are those described above (Figure 9).

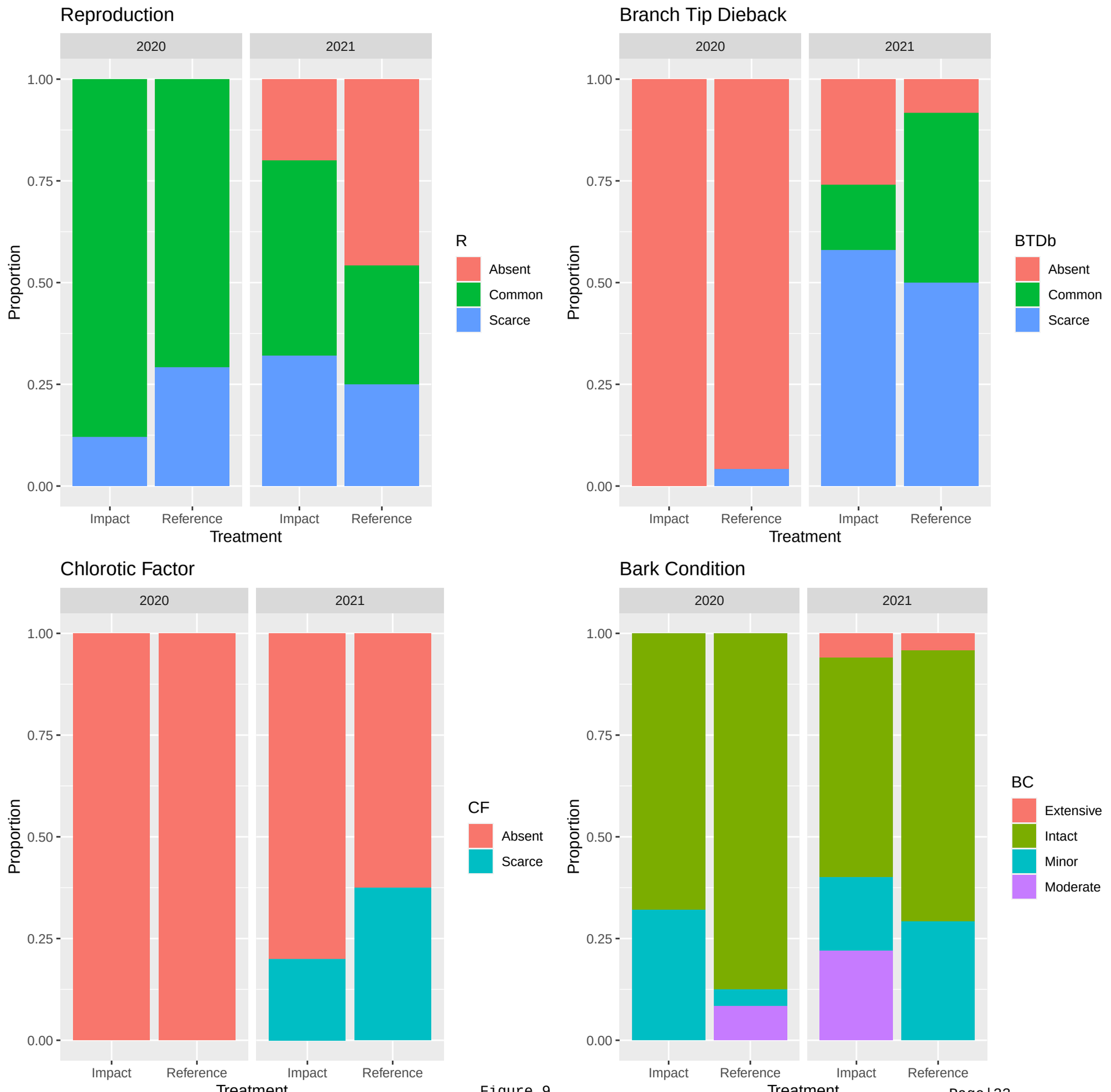

Reproduction
2020
2021
1.00
0.75
0.50
0.25
0.00
Proportion
Impact
Reference
Impact
Reference
Treatment
R
Absent
Common
Scarce
Branch Tip Dieback
2020
2021
1.00
0.75
0.50
0.25
0.00
Proportion
Impact
Reference
Impact
Reference
Treatment
BTDb
Absent
Common
Scarce
Chlorotic Factor
2020
2021
1.00
0.75
0.50
0.25
0.00
Proportion
Impact
Reference
Impact
Reference
Treatment
CF
Absent
Scarce
Bark Condition
2020
2021
1.00
0.75
0.50
0.25
0.00
Proportion
Impact
Reference
Impact
Reference
Treatment
BC
Extensive
Intact
Minor
Moderate

Figure 9

Photographs of all trees monitored within the riparian quadrats for April 2021 and October 2021 are presented in Appendix I.

6.2.2 Other comments

Assessments using the Schomaker et al. (2007) method provide a very general indication of tree health, which can be used as a standard measure across botanists. This assessment, however, was designed for European trees which generally have a different canopy type to Australian eucalypts. Furthermore, eucalypts in the Pilbara are regularly damaged during cyclones and 'crown dieback' (one of the assessment measurements used in this method) is the result of wind damage. This is a natural phenomenon, not the result of fungal or insect infestation which indicate stress. Dead twigs and branches on eucalypts in the Pilbara are not necessarily a sign of poor condition. Indicators such as leaf damage and leaf die-off (when assessed out of leaf shed season) may be more accurate for assessing impacts and stress associated with the riparian vegetation.

It is also considered that many of the trees originally selected for monitoring within the riparian sites are situated too close to each other, with foliage from trees overlapping, making estimates of foliar cover very difficult.

7 Conclusions and Recommendations

Statistical analyses on the monitoring data suggest that there are no significant differences between the Impact and Reference sites in terms of cover or species richness for the different seasons (ie post-wet vs post-dry) for the period 2020-2021. The significant difference observed in changes in sum of foliar cover between 2020 and 2021 is most likely due to a change in observer, rather than an actual decline in vegetation abundance. Qualitative and photographic monitoring between 2020 and 2021 support the statistical analyses and indicate both the terrestrial and riparian vegetation do not exhibit signs of any potential impact from the Whim Creek operations.

The number of Impact and Reference quadrats necessary for statistical analyses between sites would be prohibitive in terms of time and cost for a small operation like Whim Creek. Results of monitoring over the past two years (2020 and 2021) and also monitoring conducted previous to this (Astron 2013, 2014) would suggest that vegetation has been naturally healthy (ie. will become defoliated, dry and died back in the dry season, then regenerates in the wet season) for many years.

Two monitoring sites, WC-TV-02, an Impact site, and WC-TV-11, a Reference site, were not monitored in October 2021. The Impact site had been totally encompassed into a track leading to a borrow pit and was no longer available for monitoring. The Reference site was located on an old bottle dump which has been disturbed in the past, is covered in a mantle of broken bottles and the species of hummock grass that has established there is not representative of that found at the Impact sites.

Quadrats WC-TV-07 and WC-TV-08 are Impact sites established on old, rehabilitated sites which are slowly revegetating. These sites have been established to monitor for any potential impacts from the leach pad, however their previously disturbed status must always be considered, and they cannot be suitably compared with any of the Reference sites.

Reference quadrats WC-TV-06 and WC-TV-12 are on landforms not comparable to the Impact quadrats, and Impact quadrat WC-TV-09 is not comparable to any other Impact or Reference quadrat.

Similar to vegetation health of terrestrial vegetation, riparian vegetation both within the Impact and Reference areas was found to be healthy between 2020 and 2021, and this was also evident in previous monitoring (Astron, 2013, 2014).

The individual trees within many of the riparian monitoring sites are located too close together to accurately assess crown density and foliar transparency. Trees selected for monitoring should be suitably spaced to allow an accurate estimation of foliar cover.

Some Reference sites included *Corymbia opaca* but this species was not represented in the Impact sites so they could not be used in the analysis.

The tree health assessment scale (Schomaker *et al* 2007 and Souter 2010) is not considered to be appropriate by the field botanist. This scale is designed for European type trees with dense, relatively regular canopies, not for Pilbara eucalypts with very open, irregular, but still healthy canopies. In addition to this, the assessor involved in Pilbara vegetation monitoring, especially of riparian tree vegetation, needs to be aware of the "natural impacts" of cyclones and very strong winds, of prolonged drought and of natural phenological changes such as shedding of older leaves and the growth of new leaves in the third quarter of the year.

A discussion needs to be had with DWER to formulate ways to modify and refine the monitoring program to capture any potential impacts, more effectively, from the Whim Creek operations on terrestrial and riparian vegetation. Some initial recommendations are made below.

Recommendations: Terrestrial Vegetation Monitoring

It is recommended that prior to any monitoring in 2022, the terrestrial monitoring program be modified to better address the monitoring objectives and the requirements specified in the EPN Amendment dated 15th May 2020 (Ref No. DWERDG804/19).

This would include, but not be limited to:

- installing more Reference sites, ensuring they are comparable with Impact landform and vegetation type;
- the reselection of some Impact sites so that suitable Reference sites can be used as a comparison;
- utilizing a less subjective vegetation condition scale (eg. the one adapted from Keighery (1994) and Kaesehagen (1995) as suggested by DWER);
- install more quadrats of a reduced area and adopt a more targeted approach to better assess health. (eg it may be more advantageous to monitor just dominant/common/indicator species such as *Triodia* sp., and *Acacia* sp. or select three or four species in the different life form classes (grasses/shrubs/trees) allowing the focus on important vegetation components over numerous sites, providing a more robust monitoring program.
- monitoring to be reduced to once annually (timing must be consistent, ie. either wet or dry season). Monitoring should also occur in the event of a rainfall event greater than a 1 in 5 year, 72 hour event or in the event of any known operational process breach or leakage.

Recommendations: Riparian Vegetation Monitoring

- It is recommended that prior to any monitoring in 2022, the riparian monitoring program be modified to better address the monitoring objectives and the requirements specified in the EPN Amendment dated 15th May 2020 (Ref No. DWERDG804/19).

This would include, but not be limited to:

- installing more Reference sites
- reducing the number of monitoring criteria assessed to target the most telling criteria, thus providing more robust monitoring results
- change health assessment scale to one more appropriate to the habit of eucalypts.
- Select monitoring trees within current sites which are spaced further from each other and therefore more able to be accurately assessed.

Whilst modifying the programme at this stage means that the 2020 and 2021 data will not be directly comparable with the data from the new program, it will remain valid in as much as it indicates that vegetation during those years was healthy. Similarly, the Astron (2013, 2014) data can also be referred to which also indicates a lack of any impacts from the Whim Creek operations, and the Astron (2019) report which describes the impacts of a leak incident which occurred in 2019.

8 References

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APPENDIX A

Vegetation Classification and Vegetation Condition Scales

Table A.1: Vegetation Classification System Specht (1970) as modified by Aplin (1979).

Stratum	70-100% cover	30-70% cover	10-30% cover	2-10% cover	<2% cover
Trees > 30 m	Tall closed forest	Tall open Forest	Tall woodland	Tall open woodland	Scattered tall trees
Trees 10-30 m	Closed forest	Open forest	Woodland	Open woodland	Scattered trees
Trees < 10 m	Low closed forest	Low open forest	Low woodland	Low open woodland	Scattered low trees
Shrubs > 2 m	Tall closed scrub	Tall open scrub	Tall shrubland	Tall open shrubland	Scattered tall shrubs
Shrubs 1-2 m	Closed heath	Open heath	Shrubland	Open shrubland	Scattered shrubs
Shrubs < 1 m	Low closed heath	Low open heath	Low shrubland	Low open shrubland	Scattered low shrubs
Hummock grasses	Closed hummock grassland	Hummock grassland	Open hummock grassland	Very open hummock grassland	Scattered hummock grasses
Grasses, sedges, herbs	Closed tussock grassland/ sedgeland/ herbland	Tussock grassland/ sedgeland/ herbland	Open tussock grassland/ sedgeland/ herbland	Very open tussock grassland/ sedgeland/ herbland	Scattered tussock grasses /sedges/herbs

Table A.2. Vegetation condition scale adapted from Keighery (1994) and Trudgen (1988)

Condition	**Descriptive Features**
Excellent	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
Very Good	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
Good	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.

Condition	Descriptive Features
Degraded	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species present including very aggressive species.
Completely degraded	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

APPENDIX B

Erosion Features as per Tongway and Hindley (2004)

Table B.1: Erosion Features as per Tongway and Hindley (2004)

Erosion Type	Description
Sheeting or sheet erosion (E)	The progressive removal of very thin layers of soil across extensive areas, with few if any sharp discontinuities to demarcate them. This is not always easy to detect with assurance and may need to be inferred from other soil surface features, such as downslope eroded materials, or surface nature. It is sometimes confused with scalded surfaces, but characteristically is associated with gradational or uniform textured soils.
Pedestalling (P)	The result of removing soil by erosion of an area to a depth of at least several cm, leaving the butts of surviving plants on a column of soil above the new general level of the landscape. Exposed roots are a hallmark of this erosion form. This is a sign that the soil type itself is very erodible and that loss of vegetation in the landscape was preceded by erosion, and not the other way about. Often associated with stones in the post mining environment.
Rills and gullies (R)	Are channels cut by flowing water? Rills are less than 300 mm deep and gullies are greater than 300 mm deep. They may be initiated by water flowing down sheep or cattle paths. Their presence is a sure sign that water flows rapidly off the landscape, often carrying both litter and soil with it. They are aligned approximately with the maximum local slope.
Terracettes (T)	Are abrupt walls from one to 10 cm or so high, aligned with the local contour, Terracettes progressively cut back up-slope, the eroded material being deposited in an alluvial fan downslope of the feature. The location of a terracette will be noted in the comments of the landscape organisation sheet for the line transect so that its progress upslope can be monitored over time. A change of zone will occur at the location of the terracette and it is assessed as occurring in the upslope zone (i.e. it will have an Erosion type and Severity class value of one or two. The erosion type downslope of the terracette may be sheeting with alluvial deposits.
Scalding (S)	Is the result of massive loss of A-horizon material in texture-contrast soils which exposes the A2 or B horizon which are typically very hard when dry and have extremely low infiltration rates? Scalds have a productive potential of zero, and pond or shed water readily. They are often on flat landscapes, though not exclusively, whereas sheeting is on gentle slopes.

APPENDIX C

Qualitative Measurement Scale for Crown Density and Foliar Transparency as adapted by Schomaker et al. (2007) and Souter (2010)

Table C.1: Qualitative Measurement Scale (Schomaker et al. 2007)

Score	Percentage Measurement	Score	Percentage Measurement
0	<1%	55	50 – 55%
5	1 – 5%	60	55 – 60%
10	5 – 10%	65	60 – 65%
15	10 – 15%	70	65 – 70%
20	15 – 20%	75	70 – 75%
25	20 – 25%	80	75 – 80%
30	25 – 30%	85	80 – 85%
35	30 – 35%	90	85 – 90%
40	35 – 40%	95	90 – 95%
45	40 – 45%	100	95 – 100%
50	45 – 50%		

Units are recorded in five-percent classes and scored as 0, 5, 10, 15, . . . , 100, where the score represents the upper limit of the class, e.g., one to five percent is score five (Schomaker et al. 2007)

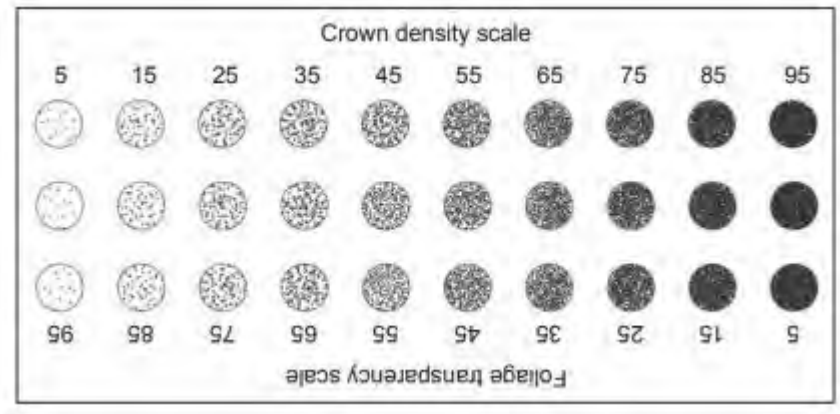

Figure C.1: Illustration Guide to Determine Crown Density and Foliage Transparency Scale (Schomaker et al. 2007)

APPENDIX D

Visual Health Score of Key Tree Features (adapted from Souter et al. 2010)

Table D.1 Visual Health Score of Key Features

Score	Health Ranking	Description
Reproduction		
1	Absent	Effect is not visible
2	Scarce	Effect is present within the assessable crown but not readily visible
3	Common	Effect is clearly visible through the assessable crown
Branch tip Die-back		
1	Absent	Effect is not visible
2	Scarce	Effect is present within the assessable crown but not readily visible
3	Common	Effect is clearly visible through the assessable crown
Presence of Mistletoe		
1	Absent	Effect is not visible
2	Scarce	Effect is present within the assessable crown but not readily visible
3	Common	Effect is clearly visible through the assessable crown
Chlorotic (yellowing) Foliage		
1	Absent	Effect is not visible
2	Scarce	Effect is present within the assessable crown but not readily visible
3	Common	Effect is clearly visible through the assessable crown
Bark Condition		
0	Intact	Intact bark
1	Minor	Minor cracks
2	Moderate	Moderate bark cracks
3	Extensive	Extensive bark cracks
Total Score		
4	Very Healthy	Tree shows no visible signs of poor health attributes
5 - 10	Healthy	Tree shows minimal signs of poor health attributes
11 – 14	Unhealthy	Tree shows moderate signs of poor health attributes
15	Extremely Unhealthy	Tree shows significant decline and abundant poor health attributes

APPENDIX E

P-value Tables for Terrestrial and Riparian Vegetation

Table E.1: P-values for differences between Impact and reference treatments for categorical tree health variables.

Health Parameter	2020	2021
Bark Condition	**0.00534**	0.0798
Branch Tip Dieback	0.146	**0.0291**
Chlorotic Factor		0.107
Reproduction	0.0693	0.0654

Table E.2: P-values for differences between Impact and Reference treatments for continuous tree health variables.

Health Parameter	p-value
Crown Density change	0.162
Crown Dieback change	0.054
Foliage Transparency change	0.0664

Table E.3: P-values for differences between years for each of the Impact and Reference treatments for categorical tree health variables.

Health Parameter	Impact	Reference
Bark Condition	0.000791	0.0425
Branch Tip Dieback	1.77E-13	9.47E-09
Chlorotic Factor	0.000858	0.000874
Reproduction	0.0000367	0.00049

Table E.4: P-values for differences between Impact and Reference treatments for continuous terrestrial vegetation variables.

Vegetation Parameter	p-value
Wet Season Cover	0.316
Dry Season Cover	0.367
Wet Season Sp. Richness	0.503
Dry Season Sp. Richness	0.788

APPENDIX F

Vegetation Descriptions for the Terrestrial Quadrats

VEGETATION DESCRIPTONS 2020 (360) and 2021 (VLA)

Quadrat No	2020 Vegetation Description (360)	2021 Vegetation Description (VLA)	Comment
WC-TV-01	*Corymbia opaca* low open woodland over *Acacia bivenosa, Acacia arida* and *Acacia ancistrocarpa* tall shrubland over *Acacia pyrifolia, Scaevola spinescens* and *Senna notabilis* mid to low sparse shrubland over *Triodia epactia* and *Triodia wiseana* low closed hummock grassland.	*Corymbia opaca* scattered low trees over *Acacia bivenosa, Acacia arida* open tall shrubland over *Acacia pyrifolia* open shrubland over *Triodia epactia* with *Triodia lanigera* hummock grassland.	Corymbia trees are very scattered; *Acacia ancistrocarpa* and *Scaevola spinescens* were not recorded in the quadrat in either 2021 visit (the very low *Scaevola browniana* was at <2%). The hummock grassland was not "closed" (70-100%) and no *Triodia wiseana* was present.
WC-TV-02	*Acacia victoriae* and *Hakea lorea* subps *lorea* tall sparse shrubland over *Acacia pyrifolia, Acacia ancistrocarpa* and *Acacia arida* mid sparse shrubland over *Acacia bivenosa, Corchorus tectus, Sclerolaena* sp and *Senna notabilis* low sparse shrubland with *Triodia epactia* low closed hummock grassland.	*Acacia arida, Acacia pyrifolia, Acacia ancistrocarpa, Hakea lorea* subsp *lorea* scattered to open shrubland over *Acacia stellaticeps,* open low shrubland with scattered *Corchorus elachocarpus* over *Triodia epactia* hummock grassland. There are very scattered *Heliotropium muticum* (Priority 3 species). Quadrat was removed during 2021.	*Acacia synchronicia* was recorded, potentially mis-identified as *A. victoriae* but only <2%. Low shrubs of *Acacia bivenosa* were recorded as <2% but *Acacia stellaticeps* was slightly more abundant at 2%. The hummock grassland is not "closed".
WC-TV-03	*Acacia synchronicia* tall shrubland over *Acacia victoriae, Acacia pyrifolia* and *Acacia bivenosa* mid open shrubland over *Triodia epactia* and *Triodia angusta* low closed hummock grassland over *Eragrostis xeophila* low sparse tussock grassland with *Neptumia dimorphantha* low sparse shrubland.	*Acacia synchronicia* tall open shrubland with *Acacia pyrifolia* and *Acacia bivenosa* over *Triodia epactia, Triodia longiceps* hummock grassland. There is very sparse (2%) *Eragrostis xerophila* tussock grassland in one corner of the quadrat.	The quadrat is placed so that one corner covers a lower drainage area with more clayey soils, hence the small intrusion of tussock grass *Eragrostis xerophila* into the quadrat. *Triodia angusta* was not present. Hummock grassland is not "closed" (70-100%). *Neptunia dimorphantha* is a small, usually prostrate perennial herb (not shrubland) which was recorded at <2% in April 21.
WC-TV-04	*Acacia pyrifolia, Acacia bivenosa* and *Acacia arida* tall closed shrubland over *Hakea lorea* subsp *lorea, Acacia syrnchronicia* and *Tephrosia* sp NW Eremaean mid sparse shrubland over *Triodia epactia* and *Triodia angusta* low closed hummock grassland over *Indigofera monophylla* low sparse shrubland with *Eragrostis xerophila* low sparse tussock grassland.	*Acacia arida, Acacia pyrifolia, Acacia bivenosa* tall shrubland with scattered *Grevillea pyramidalis*, over *Indigofera monophylla* scattered low shrubs over *Triodia epactia* with *Triodia longiceps* hummock grassland.	"Closed" tall shrubland indicates the tall shrub cover is 70-100%, rarely found in the Pilbara (occasionally along a fire impacted creek line) but certainly not in quadrat 4. *Grevillea pyramidalis* seems to have been mistaken for *Hakea lorea. Tephrosia* sp NW Eremaean is a small prostrate or spreading herb, generally not more than 10 cm tall – it cannot be classified as "shrubland".

Quadrat No	2020 Vegetation Description (360)	2021 Vegetation Description (VLA)	Comment
			Triodia angusta is mistaken for *T. longiceps* and the *Eragrostis xerophila* is less than 2% - ie very scattered. Hummock grassland is not "closed"
WC-TV-05	*Acacia ancistrocarpa, Acacia bivenosa, Acacia pyrifolia* tall shrubland over *Triodia epactia* and *Triodia wiseana* low closed hummock grassland with *Corchorus tectus* and *Senna notabilis* low open shrubland over *Bonamia pannosa* low sparse forbland.	*Acacia ancistrocarpa, Acacia bivenosa, Acacia pyrifolia* tall shrubland over *Corchorus elachocarpus* open low shrubland with scattered *Heliotropium muticum* (P3) over *Triodia epactia* with some *Triodia lanigera* hummock grassland.	Hummock grassland is not "closed" and *Triodia wiseana* is not present. *Corchorus* has been misidentified. *Bonamia pannosa* is a very small prostrate herb generally occurring as scattered individuals – recorded as <2% by VLA.
WC-TV-06	*Acacia inaequilatera* and *Acacia ancistrocarpa* tall open shrubland over *Acacia arida, Senna glutinosa* subsp *glutinosa, Acacia pyrifolia* and *Ptilotus calostachyus* mid shrubland over *Triodia epactia* low closed hummock grassland over *Acacia bivenosa* low sparse shrubland.	*Acacia inaequilatera* open tall shrubland over *Acacia arida, Acacia ancistrocarpa* open shrubland over *Triodia epactia* hummock grassland. There are scattered *Senna glutinosa* subsp *glutinosa, Grevillea pyramidalis, Acacia bivenosa..*	Hummock grassland is not "closed". It was estimated in this quadrat to be 50 - 60% cover.
WC-TV-07	*Acacia acradenia, Acacia ancistrocarpa, Acacia inaequilatera, Acacia bivenosa, Acacia pyrifolia* tall open shrubland over *Triodia epactia* low open hummock grassland over *Senna notabilis* low sparse shrubland.	*Acacia bivenosa* with *Acacia acradenia, Acacia inaequilatera* tall open shrubland over *Triodia epactia* open hummock grassland.	Old revegetation site.
WC-TV-08	*Acacia arida*, *Acacia ancistrocarpa*, *Acacia acradenia* and *Acacia pyrifolia* tall shrubland over *Acacia tumida* var. *pilbarensis* mid sparse shrubland over *Triodia epactia* low open tussock grassland over *Corchorus tectus* and *Senna notabilis* low sparse shrubland over *Aristida contorta* low sparse tussock grassland	*Acacia acradenia* tall shrubland with *Acacia pyrifolia* and scattered *Acacia ancistrocarpa, Acacia tumida* var *pilbarensis* over *Corchorus tectus* open low shrubs over *Triodia epactia* open hummock grassland.	VLA recorded *Acacia arida* and *Acacia ancistrocarpa, A. tumida* at <2% and therefore very scattered. *Aristida contorta* is a short lived annual grass, VLA recorded it at <2%.
WC-TV-09	*Acacia inaequilatera*, *Acacia ancistrocarpa* and *Acacia pyrifolia* tall open shrubland over *Dolichandrone occidentalis* and *Acacia arida* mid sparse shrubland over *Triodia epactia* low tussock grassland over *Senna notabilis*, *Sida clementii* and *Cajanus cinereus* low sparse	*Acacia inaequilatera* tall shrubland with *Acacia ancistrocarpa,* over *Senna artemisioides* subsp *oliogophylla* open low shrubland over *Triodia epactia* hummock grassland. There are scattered *Dolichandrone occidentalis,* mostly dead, and scattered tussocks of *Eragrostis eriopoda.*	Both *Dolichandrone occidentalis* and *Acacia arida* are <2% (only 1 very small *A. arida* shrub occurs here). *Senna artemisioides* subsp *oligophylla* and *Senna helmsii* were both recorded by VLA (2-5% and <2% respectively) but not *Senna notabilis.*

Quadrat No	2020 Vegetation Description (360)	2021 Vegetation Description (VLA)	Comment
	shrubland over *Cleome viscosa*, *Trianthema pilosum*, *Goodenia microptera*, *Evolvulus alsinoides* var *villosicalyx* and *Oldenlandia crouchiana* low sparse forbland.		
WC-TV-10	*Acacia ancistrocarpa*, *Acacia inaequilatera*, *Acacia tumida* var.*pilbarensis* and *Hakea lorea* subsp. *lorea* tall shrubland over *Acacia pyrifolia* mid sparse shrubland over *Triodia epactia* low closed hummock grassland over *Cajanus cinereus*, *Corchorus tectus*, *Triumfetta clementii* and *Bonamia erecta* low shrubland over *Streptoglossa odora*, *Trigastrotheca molluginea* and *Bonamia linearis* low sparse forbland	*Acacia inaequilatera* with *Acacia ancistrocarpa, Acacia bivenosa* tall shrubland over *Indigofera monophylla, Corchorus elachocarpus* open low shrubland over *Triodia epactia* hummock grassland with *Cucumis variabilis* open vines.	*Acacia tumida* and *Hakea lorea* both have very low cover (<2%) as do the herbs listed. Hummock grassland is not closed.
WC-TV-11	*Corymbia hamersleyana* low open woodland over *Acacia inaequilatera*, *Petalostylis labicheoides* and *Acacia bivenosa* tall open shrubland over *Acacia stellaticeps* and *Acacia pyrifolia* mid sparse shrubland over *Triodia wiseana* and *Triodia epactia* low closed hummock grassland.	*Acacia inaequilatera* tall shrubland over *Triodia longiceps* closed hummock grassland, patchy *Triodia epactia*. There are very scattered (<2%) *Corymbia hamersleyana.*	This quadrat is no longer monitored as it occurs on a very disturbed area and is 50% covered in broken bottles. It is therefore not a Reference site. Additionally the dominant *Triodia longiceps* grassland (not *Triodia wiseana)* is not comparable to any of the impact sites (some do have a very minor component of this species only). *Acacia stellaticeps* was not recorded on the site.
WC-TV-12	*Acacia pyrifolia* tall open shrubland over *Senna glutinosa* subsp. *pruinosa*, *Acacia bivenosa* and *Ptilotus calostachyus* mid sparse shrubland over *Triodia wiseana* and *Triodia epactia* low hummock grassland over *Corchorus tectus* low sparse shrubland over *Ptilotus clementii* and *Ptilotus axillaris* mid to low forbland.	*Acacia pyrifolia* tall open shrubland over *Acacia bivenosa, Acacia acradenia* open shrubland over *Corchorus tectus* open low shrubland over *Triodia epactia, Triodia longiceps* mixed hummock grassland over mixed open herbland.	VLA recorded three Senna species but not *Senna glutinosa* subsp *glutinosa*. *Triodia wiseana* was not present. No weeds were recorded in 2020 but VLA recorded both **Cenchrus ciliaris* (buffel grass and **Aerva javanica* (kapok) both visits in 2021 – both <2% and as a result of the quadrat being close to a station track.

APPENDIX G

List of Flora Species recorded in the 2021 Surveys

Table G.1 List of Species recorded in the April 2021 and October 2021 surveys.

Species Recorded	April 2021	October 2021
Abutilon lepidum	X	X
Abutilon sp. (sterile)	X	
Acacia acradenia	X	X
Acacia ancistrocarpa	X	X
Acacia arida	X	X
Acacia bivenosa	X	X
Acacia inaequilatera	X	X
Acacia pyrifolia	X	X
Acacia stellaticeps	X	
Acacia synchronicia	X	X
Acacia trachycarpa	X	
Acacia tumida	X	X
Afrohybanthus aurantiacus	X	X
Alysicarpus muelleri	X	
Aristida contorta	X	X
Aristida hygrometrica	X	
Boerhavia coccinea	X	
Bonamia alatisemina	X	X
Bonamia linearis	X	X
Bonamia media	X	X
Bonamia pannosa	X	X
Bonamia rosea	X	X
Cajanus cinereus	X	X
Carissa lanceolata	X	X
Corchorus elachocarpus	X	X
Corchorus tectus	X	X
Corymbia hamersleyana	X	X
Corymbia opaca	X	X
Cucumis variabilis	X	X
Dactyloctenium radulans	X	
Dichanthium sericeum subsp. *humilius*	X	
Dolichandrone occidentalis	X	X
Enneapogon caerulescens	X	X
Eragrostis eriopoda	X	X
Eragrostis xerophila	X	X
Eremophila longifolia	X	X
Eriachne ciliata	X	X
Evolvulus alsinoides var. *villosicalyx*	X	X
Fimbristylis dichotoma	X	
Goodenia forrestii	X	
Goodenia microptera	X	X
Goodenia stobbsiana	X	X
Gossypium australe	X	
Grevillea pyramidalis	X	X
Hakea lorea	X	X
Heliotropium muticum	X	X
Heliotropium ovalifolium	X	X
Hibiscus leptocladus	X	X

Species Recorded	April 2021	October 2021
Hibiscus sturtii var. *campylochlamys*	X	X
Indigofera monophylla	X	X
Indigofera trita	X	
Neptunia dimorphantha	X	
Notoleptopus decaisnei	X	
Petalostylis labicheoides	X	
Phyllanthus maderaspatensis	X	
Pluchea ferdinandi–muelleri	X	
Pluchea tetranthera	X	
Polymeria ambigua	X	
Portulaca conspicua	X	
Pterocaulon sphacelatum	X	
Pterocaulon sphaeranthoides	X	X
Ptilotus appendiculatus	X	
Ptilotus astrolasius	X	X
Ptilotus calostachyus	X	X
Ptilotus clementii	X	X
Scaevola amblyanthera	X	X
Sclerolaena sp. well grazed sterile	X	
Senna artemisioides subsp. *helmsii*	X	X
Senna artemisioides subsp. *oligophylla*	X	X
Senna glutinosa	X	
Senna glutinosa subsp. *pruinosa*	X	X
Senna notabilis	X	X
Sida clementii	X	X
Sida echinocarpa	X	X
Sida fibulifera	X	
Sida sp. Pilbara (A.A. Mitchell PRP 1543)	X	X
Solanum diversiflorum	X	X
Sporobolus australasicus	X	
Tephrosia clementii	X	
Tephrosia rosea var. *clementii*	X	
Tephrosia sp.	X	
Tephrosia sp. NW Eremaean (S. van Leeuwen et al. PBS 0356)	X	X
Trianthema pilosum	X	
Trigastrotheca molluginea	X	X
Triodia epactia	X	X
Triodia lanigera	X	X
Triodia longiceps	X	X
Triodia wiseana	X	X
Triumfetta clementii	X	X
Waltheria indica	X	
Zornia albiflora	X	

APPENDIX H

Terrestrial Vegetation Quadrat Comparison Photos for April 2021 and October 2021

	
Site: **WC-TV-01 (I)** NW Corner (April 2021)	Site: **WC-TV-01 (I)** NW Corner (October 2021)
	
Site: **WC-TV-02 (I)** NW Corner (April 2021)	Site: **WC-TV-02 (I)** NW Corner (October 2021)
	
Site: **WC-TV-03 (**I) NW Corner (April 2021)	Site: **WC-TV-03 (I)** NW Corner (October 2021)

	
Site: **WC-TV-04 (I)** NW Corner (April 2021)	Site: **WC-TV-04 (I)** NW Corner (October 2021)
	
Site: **WC-TV-05 (I)** NW Corner (April 2021)	Site: **WC-TV-05 (I)** NW Corner (October 2021)
	
Site: **WC-TV-06 (R)** NW Corner (April 2021)	Site: **WC-TV-06 (R)** NW Corner (October 2021)

	
Site: **WC-TV-07 (I)** NW Corner (April 2021)	Site: **WC-TV-07 (I)** NW Corner (October 2021)
	
Site: **WC-TV-08 (I)** NW Corner (April 2021)	Site: **WC-TV-08 (I)** NW Corner (October 2021)
	
Site: **WC-TV-09 (I)** NW Corner (April 2021)	Site: **WC-TV-09 (I)** NW Corner (October 2021)

	
Site: **WC-TV-10 (I)** NW Corner (April 2021)	Site: **WC-TV-10 (R)** NW Corner (October 2021)

	
Site: **WC-TV-11 (R)** NW Corner (April 2021)	

	
Site: **WC-TV-12 (R)** NW Corner (April 2021)	Site: **WC-TV-12 (R)** NW Corner (October 2021)

APPENDIX I

Riparian Vegetation Tree Comparison Photos for April 2021 and October 2021

Site: WC-RV-01


Tree 1 (April 2021)


Tree 1 (October 2021)


Tree 2 (April 2021)


Tree 2 (October 2021)


Tree 3 (April 2021)


Tree 3 (October 2021)


Tree 4 (April 2021)


Tree 4 (October 2021)