Woodstock Environmental Offset Project Stage 2

Annual Progress Report

February 2023

Report prepared for Budadee Aboriginal Corporation and Pilbara Environmental Offset Program by Terra Rosa Consulting

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We acknowledge the Traditional Owners and custodians of country throughout Australia and their continuing connection to land, waters, and community. We pay our respects to the people, the cultures, and the Elders past, present and emerging.

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Project Background

For full Project Background refer to the Tharra Rehabilitation Plan: Weed Control Plan.

Since 2021, Budadee Aboriginal Corporation (BAC) in partnership with Terra Rosa Consulting (TRC), have undertaken environmental planning, monitoring and rehabilitation works across the Woodstock Abydos Protected Reserve (WAPR), as a part of the Woodstock Environmental Offset Program (WEOP). The objective of the Woodstock Environmental Offset Program, funded by the Pilbara Environmental Offset Fund (PEOF), is to enhance environmental health of Tharra (the Traditional name of the Palyku Native Title Determination Area within the WAPR), based on both cultural and conservation values. The program is currently in its second year (Stage 2).

BAC's team identified introduced weed species as a priority threat to the environmental and cultural values of the WAPR, and management of priority weed species was targeted as the focus for the WEOP. The focus for Stage 1 (2021 - 2022) was to collect information to inform future weed management actions within the riparian zones in Tharra, the exchange of botanical knowledge between Traditional Owners and scientists, and to inform the design of a vegetation monitoring approach and riparian weed control plan to guide Stage 2 of the project (known as the *Tharra Rehabilitation Plan: Weed Control Plan*). During Stage 1, Weed of National Significance (WONS) Rubber tree (*Calotropis procera*) was identified as a primary weed species of concern for Budadee. The recent increase in density and distribution of *Calotropis procera* directly threatens the rich environmental and cultural values within Tharra, particularly those within the riparian zones of the reserve.

The main objective for Stage 2 of the WEOP is to implement the *Tharra Rehabilitation Plan: Weed Control Plan,* of which the key outcome will be the improvement in condition of at least 1000 ha of vegetation within Tharra. The objectives of the *Tharra Rehabilitation Plan: Weed Control Plan* are as follows:

- Implement a targeted *Calotropis procera* management program, informed by field observations collected during Stage 1 and Traditional Knowledge and values;
- Continue mapping the distribution of weeds within the riparian zones of Tharra, to track the progress of targeted weed control program;
- Collect vegetation condition assessment data within the riparian zones of Tharra, including *Calotropis procera* density estimations, in line with established monitoring and evaluation framework methodology*;
- Further improve the capacity of the Budadee Ranger team to conduct rehabilitation and monitoring activities as per DWER's Monitoring and Evaluation Framework*; and
- Facilitate leadership from Traditional Owners in the delivery of the above objectives, ensure that Traditional Knowledge and values influence decision-making, and that cultural protocols are observed on-country.

Upon direction from DWER's PEOF Team, two of the above objectives were postponed to better align with DWER's Vegetation Monitoring Framework (under development). The varied objectives are denoted with an asterisk.

Project Logic

For full Project Logic refer to the Tharra Rehabilitation Plan: Weed Control Plan.

Budadee operates on a Caring-for-Country model. Leadership from Traditional Owners is integrated into the planning and delivery of all work programs, including the WEOP, to ensure Traditional Knowledge and values influence decision making and cultural protocols are observed while on country. The collaboration and exchange of knowledge between Traditional Owners and environmental consultants ensures that management strategies provide the best outcomes culturally and ecologically.

The objectives and trip timing outlined in the *Tharra Rehabilitation Plan: Weed Control Plan* were adapted due to the development of DWER's Vegetation Monitoring and Evaluation Framework, accommodation availability, heavy rainfall events and logistical considerations.

2022 Field Trips

Five on-country field trips were held between June and September 2022 (refer to *Table 1*). These field trips focused on targeted *Calotropis* surveys and control within the riparian areas of Tharra, with broad-scale weed mapping conducted alongside the targeted survey efforts.

The specific objectives of the five on-country field trips were as follows:

- Conduct targeted *Calotropis* surveys within the riparian areas of Tharra;
- Control all *Calotropis* plants encountered during the targeted surveys, and record the number of *Calotropis* individuals encountered and controlled;
- Map the distribution of *Calotropis* within the riparian areas of Tharra;
- Conduct broad-scale mapping of non-target weed species opportunistically during all on-country works.

Trip 3 included an on-country PEOF Consultation Workshop where Budadee Elders, Seniors and Rangers met with DWER, DBCA and TR representative to discuss management priorities within Tharra and the greater WAPR, and opportunities for future collaborations and projects to protect the cultural and ecological values of Tharra.

Table 1: Project participants and trip dates.

Project participants				
Trip 1	**Trip 2**	**Trip 3 (incl. workshop)**	**Trip 4**	**Trip 5**
26th June – 1st July	**1st – 5th August**	**15th – 18th August**	**10th – 15th September**	**26th - 30th September**
Stephen Stewart Snr. *(28/6)*	Damien Ball	Stephen Stewart Snr. *(workshop only)*	Margaret Stewart *(11/9 – 13/9)*	Biddy Norman
Margaret Stewart *(28/6)*	Michael Coffin	Irene Roberts (*workshop only)*	Damien Ball	Stephen Stewart Snr.
Stanley Ball Snr.	Danika Penson	Stanley Ball Snr.	Stanley Ball Jnr.	Margaret Stewart
Stanley Ball Jnr.	Drew Hatswell	Margaret Stewart *(workshop only)*	Amanda Stream	Amanda Stream
Damien Ball		Elizabeth Coffin	Michael Coffin	Damien Ball
Danika Penson		Michael Coffin	Davis Hicks *(11/9 – 13/9)*	Danika Penson
James Dolin		Davis Hicks *(workshop only)*	Danika Penson	James Dolin
		Danika Penson	James Dolin	
		Drew Hatswell		

Field Methodology

Targeted *Calotropis* surveys were conducted within the three major rivers/creek lines of Tharra, the Yule River, the Coorong Creek and the Turner River, as well as associated tributaries. Wherever feasible, targeted surveys were undertaken as light vehicle reconnaissance. All *Calotropis* individuals encountered during targeted surveys were recorded and controlled using the 'cut and paint' method. Broad-scale mapping of non-target weed species distribution was conducted alongside targeted *Calotropis* survey works using the QuickCapture App. Photos, GPS data and track logs were backed up at the end of each trip, and provided to the Department of Water and Environmental Regulation with this report.

The field data collection methodology was as follows:

- Track logs recorded on three handheld GPS units;
    - "GPS 1" recording from the start of the workday until the end (Total Survey Route),
    - "GPS 2" recording while within riparian areas (Targeted Survey Effort),
    - "GPS 3" recording in areas where *Calotropis* is present (*Calotropis* distribution).
- The number of *Calotropis* individuals within each occurrence area were counted and recorded in field notes;
- Non-target weed species distribution recorded as point data using the ArcGIS Application QuickCapture.

Multiple GPS units were used to record the distribution of *Calotropis procera*, targeted survey effort and all movements within the WAPR. When entering riparian areas GPS 2 was turned on to document the targeted survey effort, and when *Calotropis* was encountered the extent of the infestation was recorded as a separate track log on *GPS 3*. The number of plants and any observations were recorded in a field notebook. Weed control was conducted by the ranger team. Small *Calotropis* individuals or plants growing in loose, sandy soil were pulled out by hand, and larger *Calotropis* plants were controlled using the 'cut and paint' method.

The 'cut and paint' method entailed severing trees at their base, using either loppers or saws, and immediately 'painting' the stump with the gel herbicide Vigilant or the liquid herbicide Raizon. It is recommended that herbicide be applied to the cut stumps of *Calotropis* plants within 5 seconds (Campbell et al. 2015). Vigilant herbicide (active ingredient 4.47 g/L aminopyralid, 44.7 g/L picloram) was used throughout majority of this year's control efforts, as it has been shown to be the most effective control method (Jo Williams, Pilbara Mesquite Management Council, 2021 on-country training). In particularly dense infestation areas of the Turner River the herbicide Raizon (active ingredient 300 g/L triclopyr, 100g/L picloram) was used as a more cost-effective alternative. Vigilant and Raizon herbicides are recommended by the Department of Primary Industries and Regional Development for the chemical control of *Calotropis procera* (DPIRD, 2016).

Plate 1: Targeted Calotropis surveys being conducted in light vehicles.

Plate 2: Ranger Margaret Stewart (L) ready to apply Vigilant herbicide as Damien Ball (R) uses loppers to cut a Calotropis plant.

Plate 3: Ranger Michael Coffin (L) using QuickCapture to map weed distribution and Ranger Stan Ball Jnr. (R) tallying Calotropis plants.

Data Analysis Methodology

During the 2021 survey, it was observed that *Calotropis procera* occurrence was not uniform throughout riparian zones of Tharra. There were significant differences in occurrence in the northern (Turner) and southern (Yule) river systems, and plants tended to occur in discrete patches as either single immature plants (saplings) or as discrete concentrated populations containing mature (flowering and/or woody-stemmed plants) and immature plants. To quantify these patterns of distribution across the WAPR, densities of *Calotropis procera* were calculated on a river system scale (landscape) and local infestation scale (site-specific).

To assess differences in *Calotropis procera* densities based on catchment area, riparian zones classified by river system (Yule River, Yule River tributary etc). The relative density of each river system was calculated as the number of *Calotropis* plants per kilometre of creekline (i.e. total number of *Calotropis* plants per river system/total length (km) of targeted survey effort).

Occurrences of *Calotropis* were classified as discrete locations if they were more than 200 m from the nearest *Calotropis* individual. Eighteen discrete locations were recorded to have *Calotropis* present, and each location was assigned a code following the formula of either XTY or XY; with X = initial of the creekline, for instance T for Turner River, C for Coorong Creek; T = denotes location is within a tributary of the main creekline; and Y = number assigned to the location. Locations were numbered from north to south for Turner River and west to east for all other creeklines (refer to *Appendix 1, Map 3* for map of discreet locations, labelled infestation map in development to be supplied in final draft)

To assess patterns of infestation density at a local, site-specific density was calculated for each discrete location as the number of *Calotropis* plants per kilometre of creekline (i.e. total number of *Calotropis* plants per location/total length (km) of *Calotropis* extent per location). Each discrete location was assigned a relative density class based on the calculated density.

The five density classes were: <1 plant per km; 1-100 plants per km; 100-500 plants per km; 500-1000 plants per km and 1000 plants per km. These density classes were calculated to enable visual representation of densities across discrete locations within the WAPR and to indicate priority areas for follow-up control.

Additionally, a density rate measured as *Calotropis* plants per hectare was calculated for the three most dense locations using *Calotropis* count data and infestation extent (ha) calculated on QGIS using with satellite imagery, *Calotropis* extent data (GPS 3) and area measurement tools. This alternative density measure was calculated to assess the infestation densities within WAPR on a national scale (Campbell et al. 2015, Menge et al. 2016).

To compare *Calotropis* density and distribution between 2021 and 2022, field notes, spatial data and *Calotropis* density estimates recorded at photo-panorama monitoring locations were reviewed.

In 2021, forty photo-panorama monitoring sites were installed within the riparian areas of Tharra and opportunistic control of low density *Calotropis* infestations was undertaken. Each monitoring site was assigned a site code from WAPB PIL01 0001 - WAPB PIL01 0040. Estimations of *Calotropis procera* density were recorded at each photo-panorama monitoring sites to document changes in density over time. Based on estimated *Calotropis* densities (prior to opportunistic control) in the surrounding area, each photo-panorama monitoring site was classified into one of the following categories:

- *Riparian:* River system with no instances of *Calotropis* within 1km radius of point);
- *Low Density:* Less than 5 mature *Calotropis* individuals within 1 km radius of point;
- *Medium Density:* Greater than five mature *Calotropis* individuals, but less than 100, within 1 km radius of point. (Typically, scattered instances including flowering or seeding plants);
- *High Density*: Greater than 100 mature *Calotropis* individuals within 1 km radius of point.

In 2022, the photo-panorama sites were revisited during the targeted *Calotropis* survey works. The density estimates recorded in 2021 were compared with *Calotropis* counts and associated spatial data recorded during targeted surveys in 2022.

Field Results

Broad-scale (opportunistic) weed mapping

Broad-scale weed mapping was conducted opportunistically as light vehicle reconnaissance and on-foot surveys over five on-country trips at Tharra. The total survey route for 2022 was 1032 km, which included all movements within the WAPR during field work. Observed instances of weeds were recorded as point data using the ArcGIS application Quick Capture. Weed mapping was not conducted at areas previously surveyed in 2021 unless a notable change was observed (new growth of *Calotropis* for example). This point data indicates the presence of a weed species in the location of the record but is not representative of the total number of individuals encountered.

Six weed species were mapped, across a total of 651 observations within Tharra (refer to *Appendix 1, Map 5).* The most frequently recorded species was *Cenchrus ciliaris* (290 observations) followed by *Calotropis procera* (224 observations) and *Aerva javanica* (104 observations) (see *Table 2)*. One new species was recorded compared to 2021 (*Phoenix dactylifera,* 3 observations). Date Palm (*Phoenix dactylifera*) was observed during 2021 works but not recorded, however it was recorded by Budadee Rangers in 2022 due to concerns about the Date Palms' impact on the nearby Pulkunah Spring.

Table 2: Weed species and observation frequency recorded in the WAPR.

Introduced species	Observations
Aerva javanica	104
***Calotropis procera* (Declared Pest)**	224
Cenchrus ciliaris	290
Cenchrus setiger	8
Chloris virgata	20
Vachelia farnesiana	2
Phoenix dactylifera	3

Plate 4: Introduced species Date Palm (Phoenix dactylifera) growing at Pulkunah Spring. Photo taken in 2021.

Targeted *Calotropis* surveys and control works

Targeted *Calotropis* surveys were undertaken upon entering riparian areas within Tharra, and separate track logs were recorded to quantify survey effort, and estimate density of *Calotropis* within each river system. The Yule River, Coorong Creek, Turner River, and several minor tributaries were surveyed in light vehicles and on-foot and all *Calotropis* plants encountered were recorded and controlled using established methodology (see *Appendix 1, Map 4* for map of survey effort). A total of 106.2 km of targeted survey effort within riparian zones was conducted over the five on-country trips (see *Table 3*).

Table 3: Targeted Survey Effort (km) recorded by riparian zone.

	Yule River	Yule River Tributary	Coorong Creek	Coorong Creek Tributary	Turner River	Turner River Tributary
Trip 1	17.3	14.5	15.9	-	-	-
Trip 2	4.1	24.0	-	-	3.0	-
Trip 3	-	-	-	3.7	0.9	-
Trip 4	-	-	-	4.1	8.1	-
Trip 5	-	-	-	-	10.01	0.55
ALL TRIPS	**21.4**	**38.5**	**15.9**	**7.8**	**22.0**	**0.55**

A total of 1424 *Calotropis* plants were controlled in 2022 (see *Appendix 1, Map 1* for a map of *Calotropis* control locations). *Calotropis procera* density varied significantly between the upper catchment systems of the Turner River (Turner River and Turner River tributary) and the upper catchment systems of the Yule River (Yule River, Coorong Creek and associated tributaries. The majority of *Calotropis* plants observed were within the main body and a minor tributary of the Turner River; with a total of 1211 *Calotropis* recorded and controlled in the main body of the Turner River (relative density of 55 plants per km) and 159 plants controlled in a Turner River tributary (relative density of 289 plants per km). In comparison, just 54 *Calotropis* were controlled within the Yule River upper catchment, with the majority located within Coorong Creek (43 plants, relative density of 2.7 plants per kilometre).

Lowest densities of *Calotropis* were recorded within the Yule River tributary despite being subject to the highest targeted survey effort (0 plants over 38.5 km of targeted survey effort, refer to *Table 4*).

Table 4: Total number and relative density of Calotropis procera plants controlled in riparian areas of WAPR in 2022.

Creekline	*Calotropis procera* total numbers	*Calotropis procera* relative density (plants/km)
Yule River	8	0.37
Yule River Tributary	0	0
Coorong Creek	43	2.7
Coorong Creek Tributary	3	0.38
Turner River	1211	55.05
Turner River Tributary	159	289

Calotropis procera density by discrete location

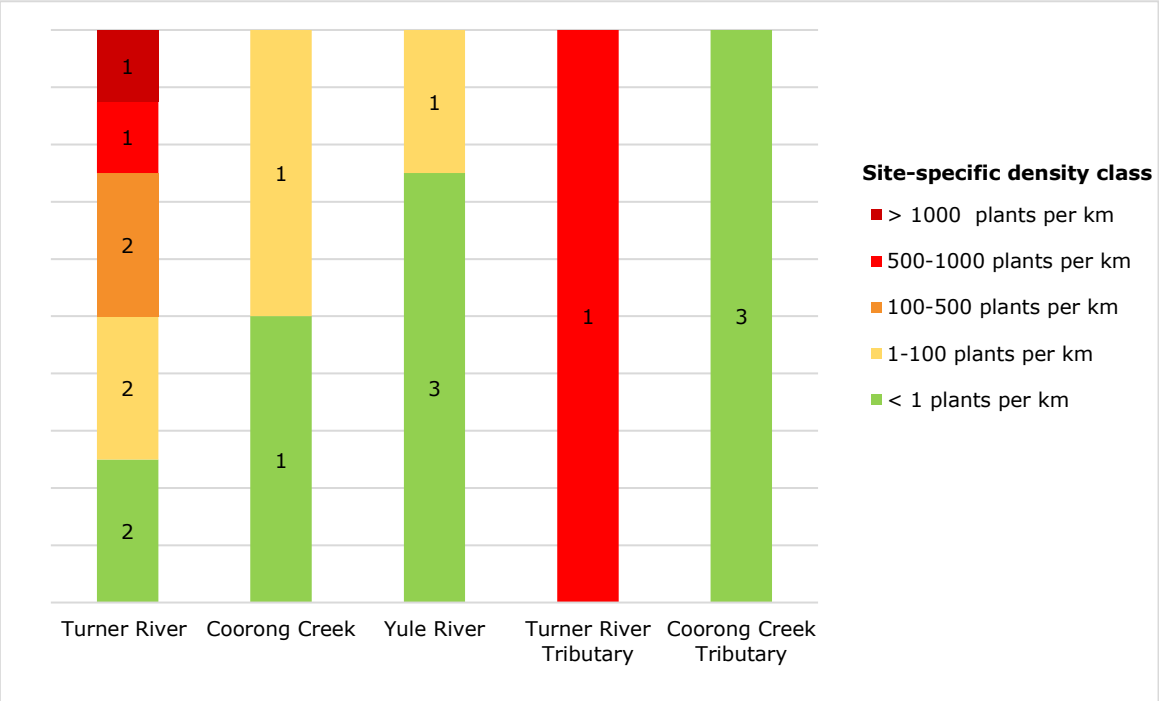
During targeted surveys, *Calotropis* was identified and controlled at a total of 18 discrete locations within Tharra in 2022; eight locations within the Turner River, one within the Turner River Tributary; four within the Yule River; two within the Coorong Creek and three within the Coorong Creek Tributary (see *Table 6*).

Table 5: Number of Calotropis procera control locations within riparian areas of WAPR in 2022.

Creekline	*Calotropis* locations
Yule River	4
Yule River Tributary	0
Coorong Creek	2
Coorong Creek Tributary	3
Turner River	8
Turner River Tributary	1

Each discrete location was assigned a code and *Calotropis* density was calculated for each location as per plants per km of creekline (refer to *Project Logic, Methodology*). Site-specific density rates ranged from <1 plant per km to 1167 plants per km across the 18 discrete locations within the WAPR. All locations with a density rate of <1 plant per km are locations with a single *Calotropis* individual.

Figure 1: Local infestation Calotropis density at discreet locations within riparian areas of WAPR in 2022. Value within vertical bar represent to number of discrete locations.



All locations with density rates of 100-500 plants per km or greater were located within the Turner River system (the main creekline or the tributary). The locations with the highest density rates were site T2, with a density of 1167 plants per km of creekline, followed by site TT1, with 719 plants per km, and site T7, with 620 plants per km. The local density rates measured in plants/ha for the three aforementioned infestations were ~262 plants/ha at site TT1, ~111 plants/ha at site T2 and ~59 plants/ha at site T7. However, as no differentiation was made between mature and juvenile plants when recording the number of *Calotropis* in the field, the density rates for locations such as T2 and TT1 were driven up by the large number of immature *Calotropis* (saplings present).

At site T7 (south of Pulkunah Spring) a high instance of re-shooting following control was observed, with majority of the mature *Calotropis* plants within this dense infestation having regrown from cut stumps (previously controlled in 2021). The lower efficiacy rate of control conducted in 2021 at site T7 compared to other sites within WAPR meant the *Calotropis* infestation in this location contained a comparatively larger proportion of mature plants. Re-shooting of plants following control was observed infrequently at other locations within the Turner River, however re-shooting was not observed at all within the Yule River, Coorong Creek or associated tributaries.

Plate 5: A Calotropis plant, south of Pulkunah Spring, re-controlled on Trip 4 after regrowing following control last year.

Calotropis distribution and density in 2021 and 2022

Approximately 1370 *Calotropis* individuals were controlled in the Turner River in 2021; and 1211 *Calotropis* individuals were controlled in the Turner River in 2022. Both the 2021 and 2022 *Calotropis* estimates include seedlings, juveniles and mature plants. However, in 2021, opportunistic control was conducted within some sections of the Turner River in 2021 hence the actual number of *Calotropis* present would have been greater than 1370.

Calotropis density at photo-panorama sites

Within the Yule River and Coorong Creek, five of the six photo-panorama sites recorded as low density *Calotropis* infestations (<5 mature plants within 1 km radius) had no *Calotropis* individuals present in 2022. There was also a reduction in the number of *Calotropis* plants present at the medium density (5-100 mature plants within 1 km radius) photo-panorama site within the Yule River (WAPB PIL01 0016). In 2021, 33 *Calotropis* individuals were recorded at WAPB PIL01 0016 prior to opportunistic control in May and follow-up control of emergent growth in August 2021. In June 2022, only five immature *Calotropis* individuals were recorded in this same area.

Within the Turner River, 15 photo-panorama monitoring sites were installed in 2021; four were classified as riparian (no *Calotropis* plants within 1 km radius), four were low density (<5 mature plants within 1 km radius), two were medium density (5-100 mature plants within 1 km radius) and five were high density (>100 mature plants within 1 km radius). One of the 11 sites with *Calotropis* present in 2021 had no *Calotropis* present in 2022 (WAPB PIL01 0037, low density). At the remaining ten sites, *Calotropis* density was reduced, with the most significant decline recorded at WAPB PIL01 0032 where over 100 mature individuals recorded in 2021 and just 10 individuals recorded in 2022.

Discussion and Management Recommendations

Summary of field observations and results

Infestations of *Calotropis* were found within all surveyed river systems of the Woodstock Abydos Protected Area (Yule River, Yule River tributary, Coorong Creek and Coorong Creek tributary [i.e. Yule River Systems], and the Turner River and Turner River tributaries [i.e. Turner River systems]). Observed patterns of *Calotropis* distribution and density remained consistent with the findings in 2021, with high levels of infestation recorded within the Turner River systems (north), and comparatively scarce instances of *Calotropis* within the Yule River systems (south). As the Turner River (north) is located over 10 km from the nearest points of both the Yule River and Coorong Creek (south), and there are no obvious direct vectors for seed dispersal (such as a main road or water flow) between the Yule and Turner river systems it is reasonable to consider them as two distinct *Calotropis* populations for management purposes.

The patterns of density and distribution of *Calotropis procera* varied significantly between the Yule River and Turner River systems. In the Turner River, *Calotropis* was recorded from 9 locations with a relative density of 60.9 plants/km (1370 plants total). Similarly, across the Yule River systems, *Calotropis* was recorded from nine locations but with a relative density of just 0.65 plants/km (54 plants total). Additionally, there were observed differences in the average maturity of *Calotropis* plants and the success rate of control conducted in 2021 between the two populations, with Turner River plants observed to be older and more resilient to control then the Yule River systems plants.

Distribution and density of *Calotropis procera* across the reserve suggests recent establishment. Even the most dense *Calotropis* infestations within WAPR, sites TT1, T2 and T7, are classified as low-medium density when compared to density classifications within literature (Campbell et al. 2015, Menge et al. 2016). There is some variation within the literature regarding the density rates considered low density with Campbell et al. (2015) identifying low density *Calotropis* stands as having <250 plants/ha; and Menge et al. (2016) referring to low density *Calotropis* stands as having <350 plants/ha. Within WAPR in 2022, the local infestation density was highest at site TT1 with a density of ~262 plants/ha, followed by ~111 plants/ha at site T2 and ~59 plants/ha at site T7.

It is recommended that *Calotropis* control be undertaken before populations reach densities that are conducive to maximum fecundity (~250-550 plants/ha) as, under favourable environmental conditions, exponential increases in *Calotropis* density can occur (Campbell et al. 2015). The early implementation of targeted control works within the WAPR will likely be effective at preventing dense, large-scale infestations, such as those seen in the De-Grey River, Brockman River and parts of the Turner Rivers outside of the WAPR, providing appropriate levels of survey effort and surveillance are maintained (Campbell et al. 2015).

Yule River System (Yule River, Coorong Creek and associated tributaries)

Within the Yule River systems, *Calotropis* plants were generally young plants or saplings, suggesting many of the plants had emerged from the seedbank following control in 2021, were too small to be observed in 2021, or were early coloniser individuals in the area. Emergence of new *Calotropis* plants from the seedbank in areas which were controlled in 2021 was observed within all river systems within Tharra, however lower rates of new plants were observed within the Yule River systems compared to the Turner River systems. Observations suggest that the prevalence of mature *Calotropis* plants correlates with high rates of emergent saplings following control, likely influenced by the build-up of a *Calotropis* seed bank by local mature plants.

The four separate occurrences of single *Calotropis* saplings growing upstream and relatively large distances (>1.5 km) from the closest *Calotropis* plant(s) were recorded within the Yule River system in 2022. It was previously predicted that, within the WAPR, *Calotropis procera seed* dispersal follows linear corridors along drainage lines, however the discovery of these four isolated individuals does not support this hypothesis. The mode of dispersal of *Calotropis* seeds at these four isolated locations is currently unknown, but likely occurred through either wind dispersal or zoochory (cattle movement) (Menge et al. 2016; Campbell et al. 2015).

Despite the lower number of controlled individuals within the Yule River systems, control actions at these sites are likely to have a high pay-off as effective control of emergent *Calotropis* individuals before maturity prevents the establishment of a seedbank and further seed dispersal (Campbell et al. 2015). The lack of mature plants recorded within the Yule River system in 2022 indicates a high level of efficiacy of control methods within this riparian zone. The minimal instances of mature plants within the Yule River indicate that lower incidences of emergent *Calotropis* individuals may be observed in 2023 (Bebawi et al. 2015).

Turner River system (Turner River and tributary)

Within the Turner River systems, *Calotropis* infestations were generally comprised of a mix of mature *Calotropis* (flowering or fruit-bearing) plants, immature plants and saplings. Mature plants controlled in 2021 were found to have a high propensity for re-shooting after treatment and required secondary control in 2022, particularly at site T7. The total number of *Calotropis* plants controlled within the Turner River systems was driven up by the large number of seedlings and immature plants which had emerged from the seedbank following control in 2021. Infestations where 2021 control works had a high success rate, such as infestation T2, were largely populated by juvenile plants hence density scores were skewed due to no differentiation between juvenile and mature *Calotropis* plants during field data collection.

The large number of *Calotropis* seedlings within the Turner River system was consistent with expectations, as large-scale recruitment is likely within the first 12 months of control programs (Campbell et al. 2015). The high numbers of immature plants found in locations that were controlled for mature plants in 2021, suggests the need to target follow-up control in more established infestations where a seed bank is present. Similarly, control efforts in low density areas incur a reduced risk of re-establishment. The incidences of mature *Calotropis* plants present within the Turner River in 2022 that had been missed during control efforts in 2021 was low, indicating the survey technique and effort undertaken in 2021 was effective.

In 2022, one previously unrecorded infestation area (site TT1) was discovered in the Turner River catchment. This area included mature and flowering *Calotropis* plants which posed a high dispersal risk. It is anticipated that a high frequency of emergent seedlings will be observed within this area in 2023, as there is likely an established seed bank in the area and soil disturbance during control works and by cattle increase both emergence and establishment of seedlings (Campbell et al. 2015). This phenomena will also likely be observed in 2023 in other areas where mature plants were present and controlled in 2022, such as infestation T3 and T7. Promotion of seedling regrowth can be advantageous if follow-up control is undertaken before the new plants reach maturity (Campbell et al. 2015), further highlighting the importance of continuing targeted *Calotropis* control surveys in 2023.

There are several factors which could possibly have contributed to the propensity for re-shooting following control including cut height, time between cutting and herbicide application, interference of chainsaw dust in herbicide absorption, herbicide efficiacy on mature plants, depth of root systems or environmental factors such as water and nutrient availability. It was observed that only plants that had transitioned from a herbaceous stem to woody trunk were found to re-shoot, and re-shooting was primarily observed in the area south of Pulkunah Spring (infestation T7).

It was observed in the field that mature *Calotropis* plants which had regrown following control had a greater number of stems than mature plants which had not been controlled in 2021, and that many of the plants which had regrown were flowering. These field observations follow the same trends observed in weed control trials conducted in Northern Australia by Campbell et al. (2015) where *Calotropis procera* plants cut at ground level but not treated with chemicals reshot vigorously and, after 8 months, had a 0% mortalit ratey, more than twice the number of stems as un-cut plants and all cut plants were flowering. These results highlight the importance of timely follow-up control, and vigilance in applying best-practice control methodology, as cutting *Calotropis* trees and not effectively applying herbicide provides very little benefit.

Comparison to 2021 *Calotropis* distribution and density

Due to differences in field data collection methodology and trip priorities in 2021 and 2022, it is difficult to directly compare field data between the two years. However, field notes and *Calotropis* density estimates recorded during the photo-panorama vegetation monitoring works conducted during 2021 provide some insight.

A small decrease in the number of *Calotropis* plants recorded in the Turner River was observed, with 1370 plants recorded in 2021 and 1211 plants recorded in 2022. This decrease is observed despite the 2021 *Calotropis* estimation reflecting the number of plants opportunistically controlled during 2021 surveys (hence not all plants encountered are included in this estimate), compared to the 2022 estimate which reflects the number of plants both encountered and controlled during targeted *Calotropis* surveys conducted in 2021.

Budadee Rangers involved in *Calotropis* control in the Turner River in both 2021 and 2022 noted a decrease in the number of mature *Calotropis* plants in the northern infestations within the Turner River, especially at infestation T2. Majority of the 244 *Calotropis* individuals controlled at infestation T2 in 2022 were seedlings

and juvenile plants which had emerged from the seedbank following control in 2021. These field observations suggest that seedlings and juvenile *Calotropis* plants comprise a greater proportion of the *Calotropis* population within the Turner River in 2022 compared to in 2021.

Calotropis procera control methodology

Given the high levels of survival in mature plants following treatment at site T7, it is recommended that new methods for controlling mature plants are explored in 2023. The efficacy of control conducted in 2022 and the frequency of re-shooting will be assessed as a priority during the first PEOF trip of 2023, so as to allow for ample time to adaptation of control methodology and planning if required. Control methods to be implemented for *Calotropis* individuals that have regrown following control may be adapted in 2023 based of field observations, published research and advice from the PMMC. Alternate control methods to the 'cut and paint' method which are viable in terms of this project are limited, due to the remoteness of the project area and the location of *Calotropis* infestations within riparian areas.

The control research trials conducted by Campbell et al. (2015) emphasise the importance of selecting control techniques based on the size and density of *Calotropis* plants. The 'cut and paint' method is identified as an effective technique for controlling isolated plants and low density infestations (such as the infestations within WAPR) (Campbell et al. 2015). Campbell et al. (2015) also recommend the use of picloram based gel (such as Vigilante) for smaller *Calotropis* plants, and the use of triclopyr/picloram herbicide (such as Raizon) for larger plants. Assessment of the efficiacy of the Raizon herbicide treatment used infestation T7 in 2022 will be a priority action in 2023, and control methodology may be adapted based off observations at this location. The frequency of re-shooting in mature plants following control undertaken in 2022 will also be assessed as a priority at newly discovered infestation TT1.

During discussions with Jo Williams from the Pilbara Mesquite Management Council (PMMC) in late November 2022, it was suggested that *Calotropis* plants which have regrown following 'cut and paint' control cannot be effectively controlled by repeating the initial control method. Control methods to be implemented for *Calotropis* individuals that have regrown following control may be adapted in 2023 based of field observations, current research and advice from the PMMC.

An alternative control method to the 'cut and paint' technique is manual control, which has been used sporadically throughout the 2022 control trips. *Calotropis* plants which had resprouted following control and which were growing in areas with minimal vegetation to stabilise the surrounding soil were often easy to physically pull out. During 2022 control works, it was noted that it was often easier to pull out more mature individuals that had regrown following control, as opposed to younger *Calotropis* individuals which had not yet been controlled growing in similar substrates. However, manual control is not suitable for all plants, especially individuals growing in densely vegetated areas, hence will continue to only be implemented opportunistically.

The PMMC are investigating the effectiveness of alternate control methods which involve drilling into the trunk and placing a tablet with a chemical or fungal control agent. As these control methods are investigated and developed, they will be

implemented as appropriate in 2023 and onwards. Any adaptations to control methodology will be made in consultation with Senior Rangers, Elders and the PEOF team.

Restricted vehicle access

The largest obstacle encountered while conducted targeted *Calotropis* surveys was limited vehicle access, particularly within the Turner River. Some sections of the Turner River were not accessed during the 2022 targeted control trips due to restricted vehicle access and high temperatures which made walking long distances from vehicles unsafe. To ensure these sections of the Turner River are subject to targeted control surveys in 2023, the first field trips will focus solely on surveying the Turner River when the temperatures are lower and more conducive to conducting surveys on foot. The Yule River and Coorong Creek will be surveyed on field trips later in the year, when temperatures will be higher, as they are largely accessible via vehicle.

The 2022 GPS Track Logs show which sections of the Turner River are accessible via vehicle and which are not, and this data will be used to create a plan for conducting a mix of walking and vehicle surveys. The attendance of the DBCA ARP Budadee Rangers on the Turner River control trips will be prioritised to ensure the maximum amount of rangers present to assist with the most challenging area within Tharra to conduct *Calotropis* control. The attendance of appropriate Seniors and Elders will also be prioritised during the planning of the Turner River control trips to ensure the cultural safety of all participants on these surveys.

Ideally, dedicated lightweight off-road vehicles (such as quad bikes or buggies) with 4WD vehicles in support would allow for more efficient and comprehensive *Calotropis* surveys. However, a range of administrative and logistical factors limit the viability of the use of lightweight vehicles within Stage 2 of the WEOP.

Long-term Management

The Woodstock Abydos Protected Reserve forms part of the upper catchment for each of these river systems, and it is hoped that effective control within WAPR will have broader impacts in reducing the spread of *Calotropis* outside the reserve. Expanding monitoring and control down-river in collaboration with regional stakeholders is encouraged for long-term control of this weed (Traditional Owners, pastoralists, mining, public sectors etc.). The management of other threats, such as feral herbivores and altered fire regimes, is also important in protecting the riparian areas within the reserve (see *Project Logic in Tharra Rehabilitation Plan: Weed Control Plan* for Integrated Riparian Management model).

The Budadee Ranger Program intends to continue to manage *Calotropis procera* and other threats within WAPR into the future. As Stage 2 of the Woodstock Environmental Offset Project closes in early 2024, we will be able to determine if it will be feasible to transition to a *Calotropis* maintenance program facilitated through Budadee's DBCA Ranger Program or whether a Stage 3 is required to continue undertaking targeted *Calotropis* control works within the reserve.

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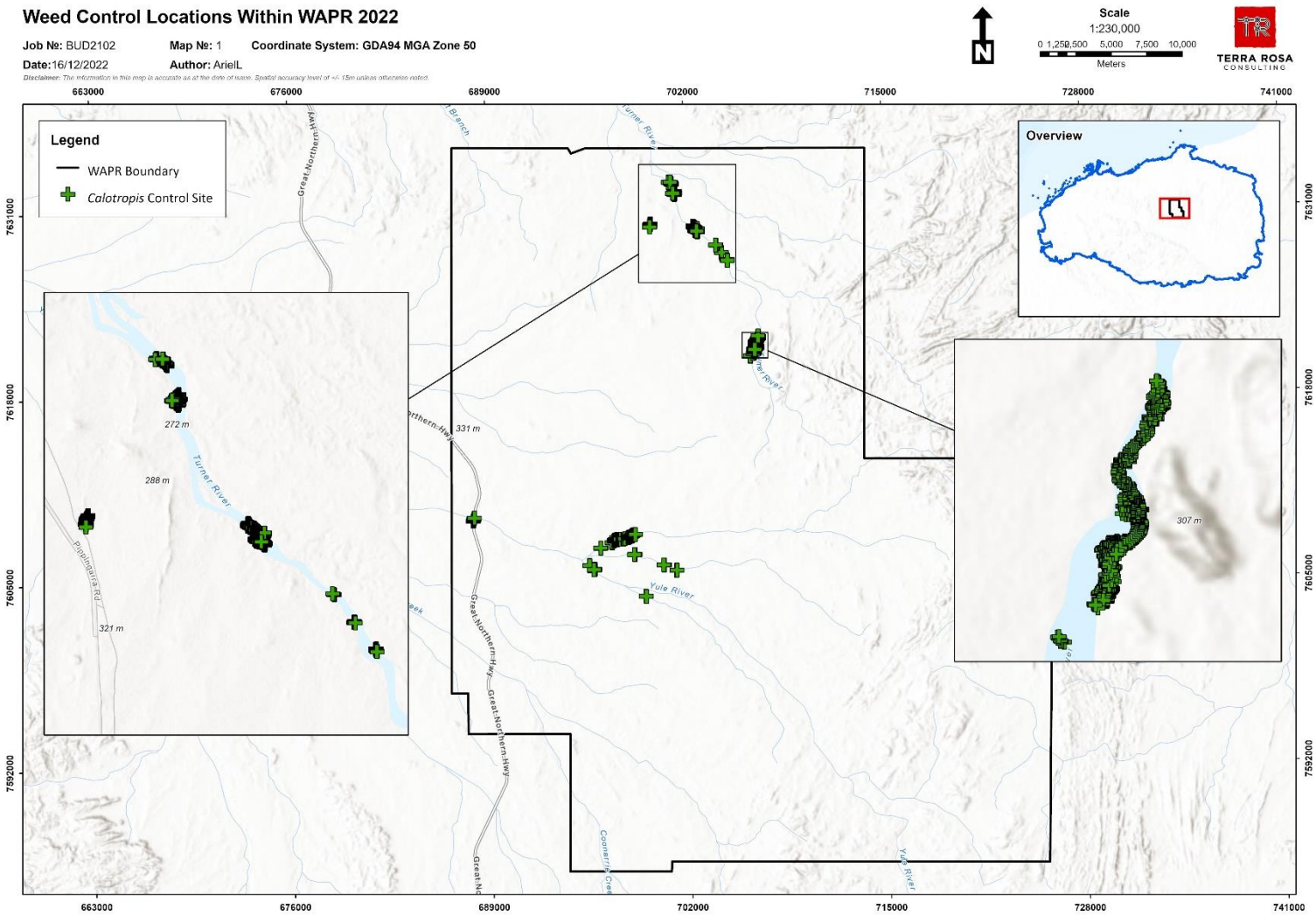
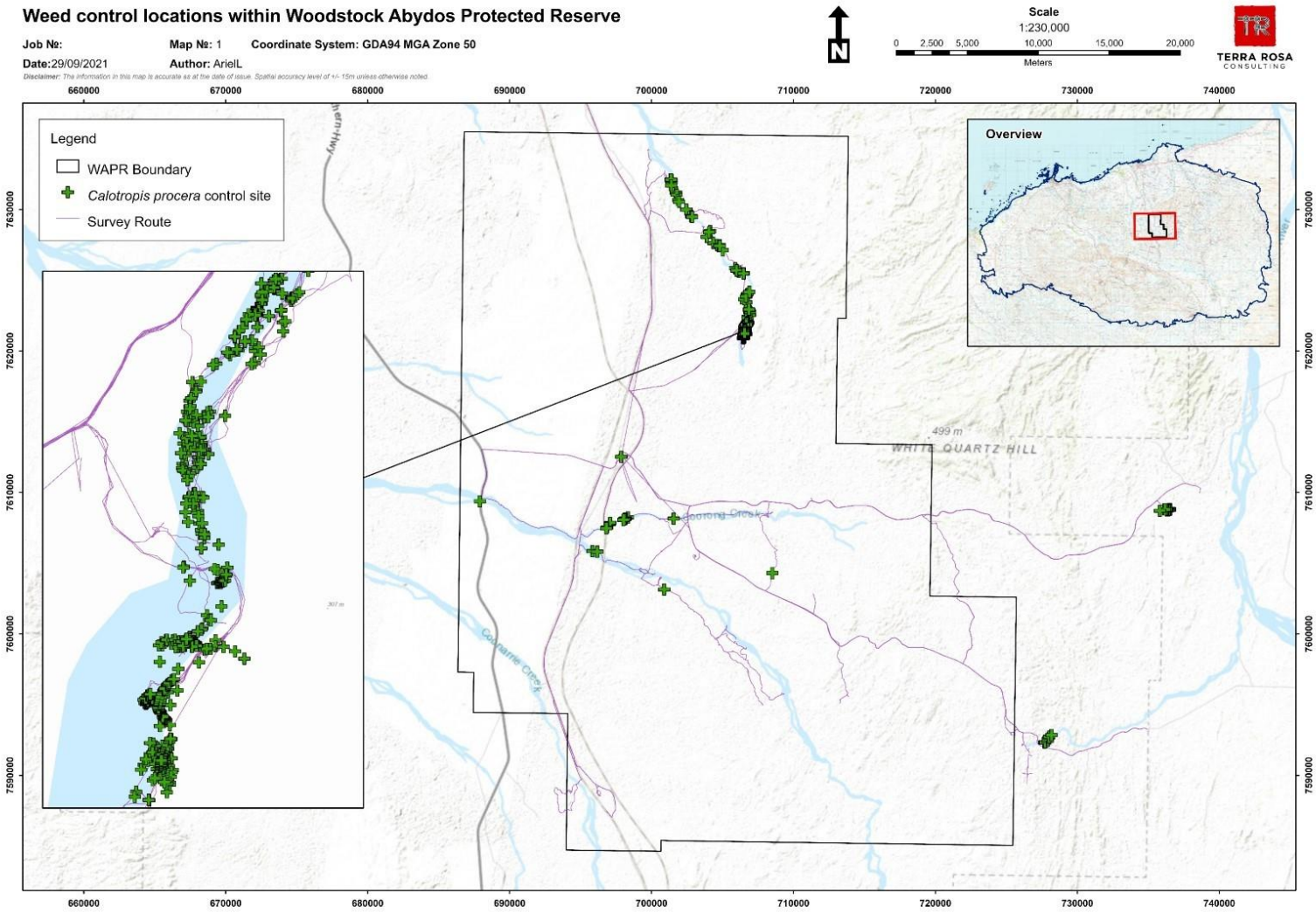
Appendix 1: Maps

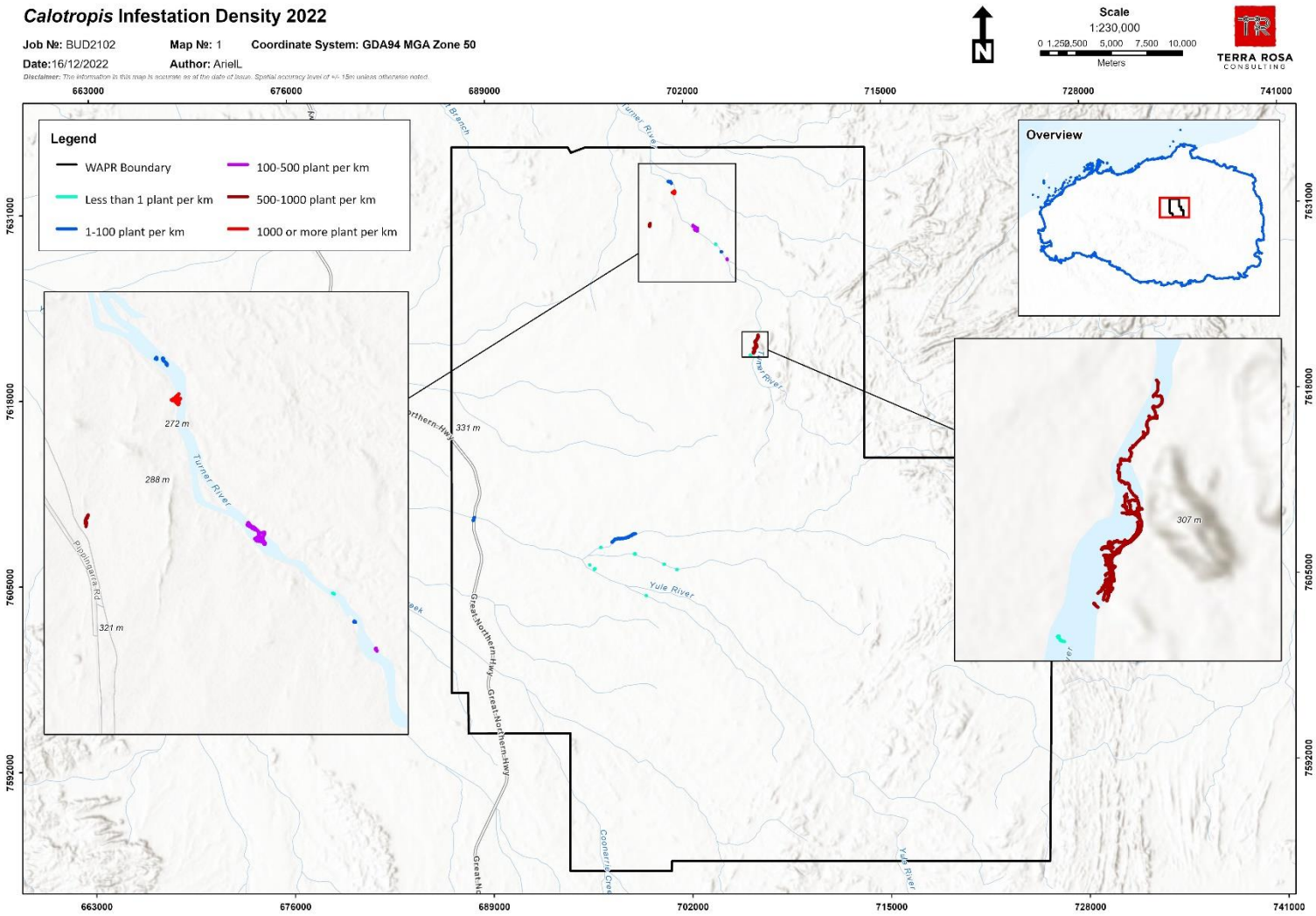
Map 1: Calotropis procera (juvenile and mature individuals) Distribution within WAPR in 2022



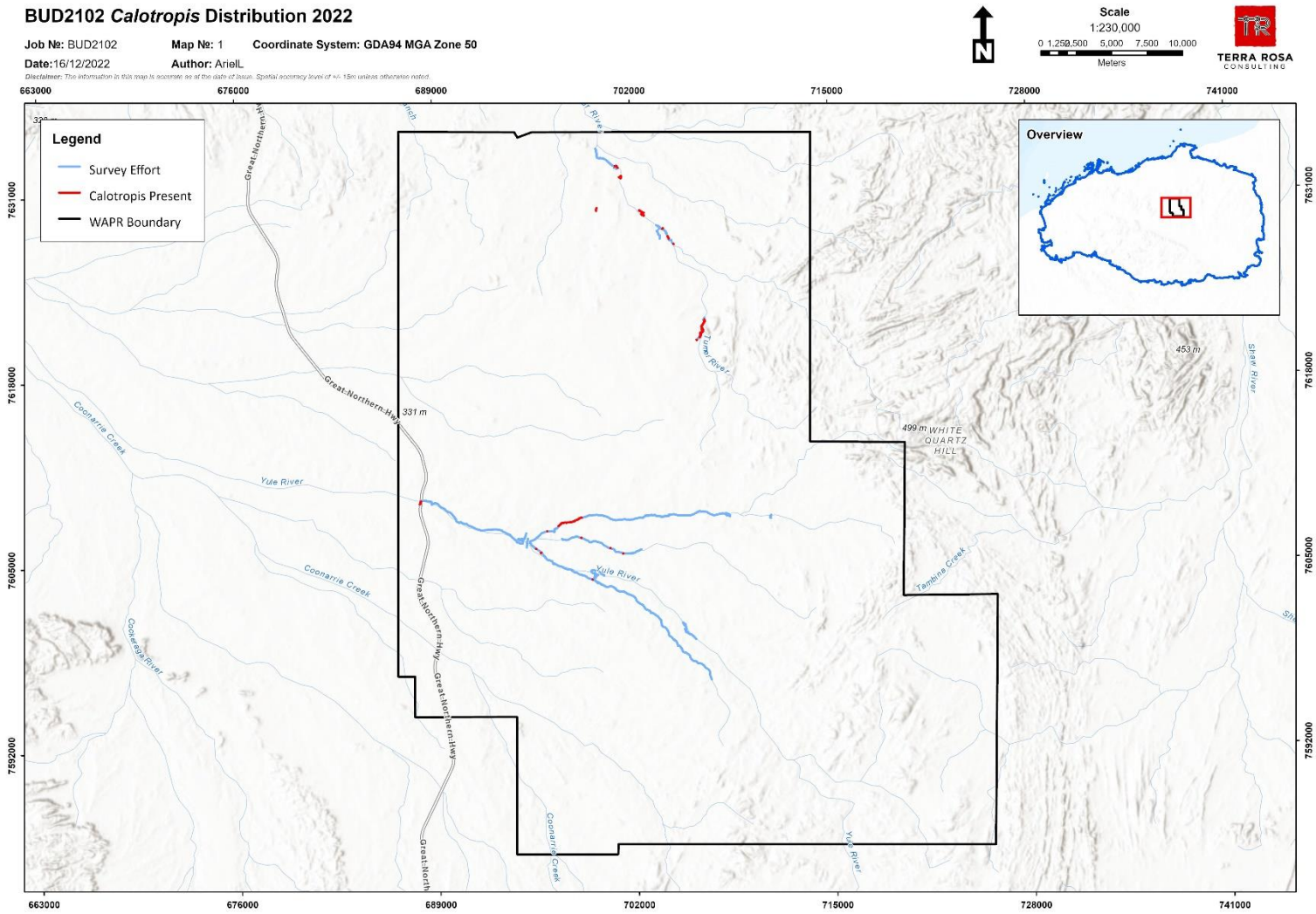
Map 2: Calotropis procera (mature individuals) Control Locations in 2021



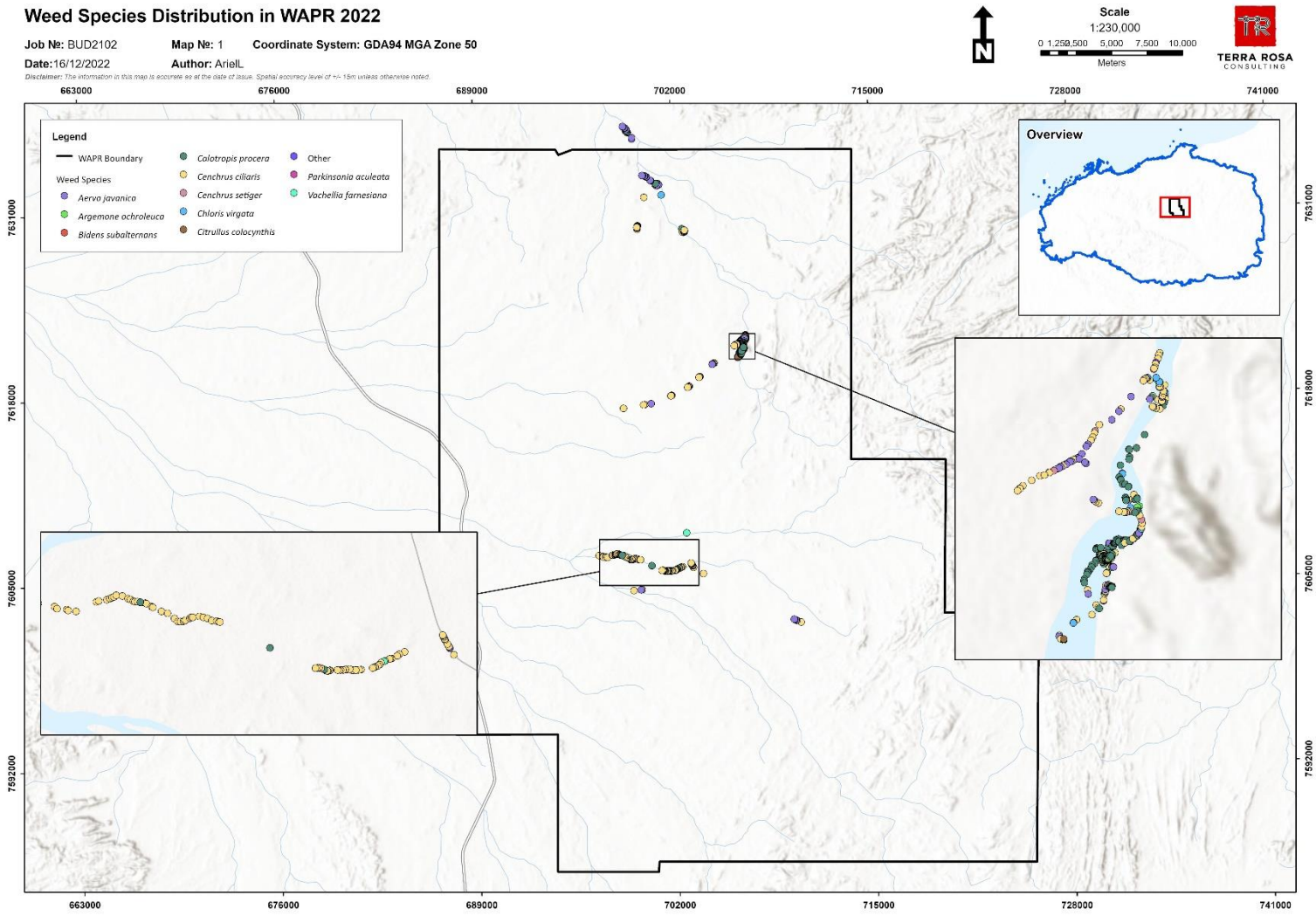
Map 3: Local infestation density of Calotropis procera within WAPR in 2022



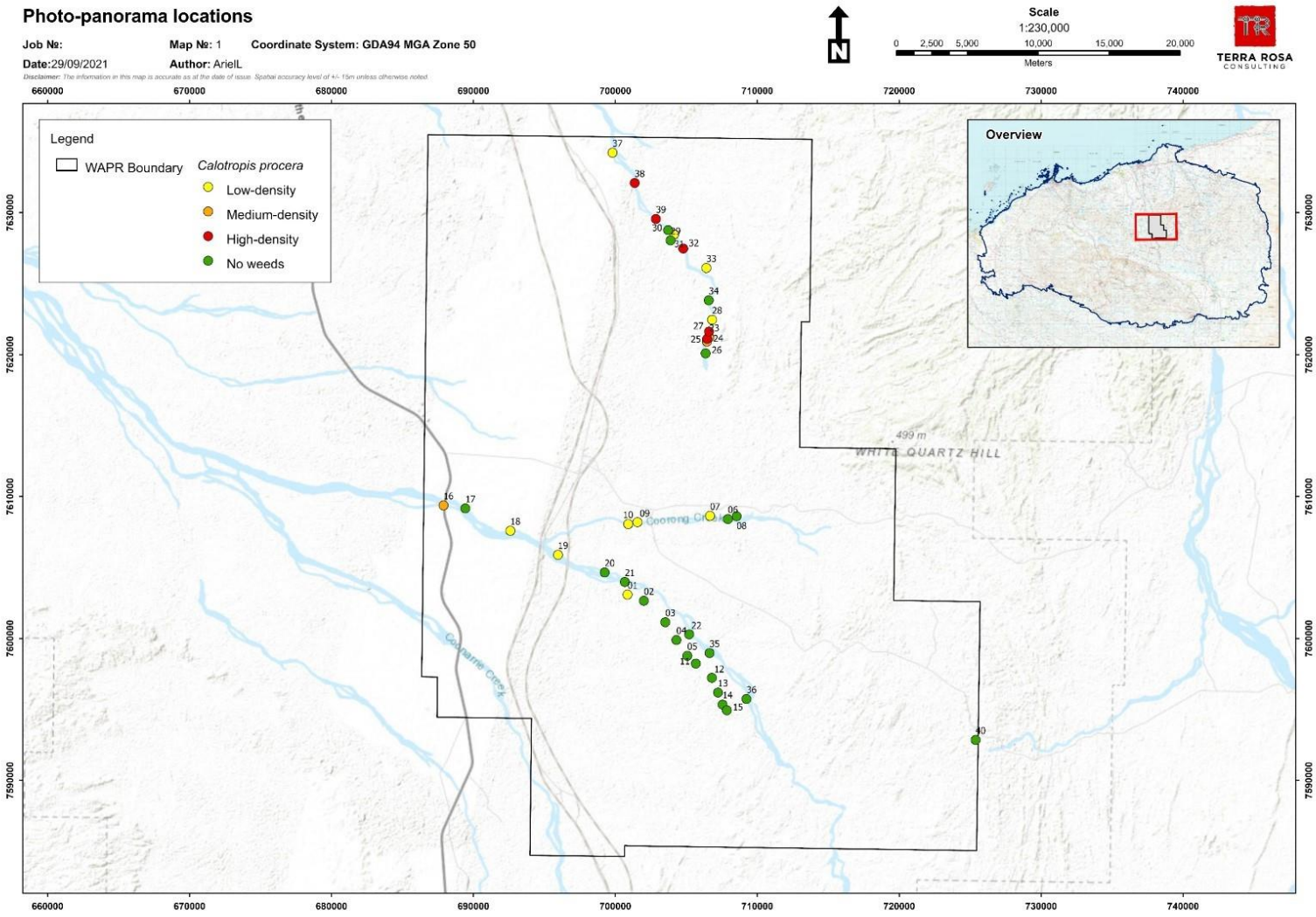
Map 4: Targeted Survey Effort and Calotropis presence within riparian areas of WAPR in 2022



Map 5: Weed Distribution in WAPR in 2022



Map X: Photo-panorama Monitoring Locations in 2021



Appendix 2: Project Contacts

Budadee Aboriginal Corporation

Address 30 Greene Place
South Hedland
WA, 6722, AUSTRALIA

Contacts Jake Milroy
Palyku Traditional Owner and
Program Contact
ezramilroy@gmail.com

Terra Rosa Consulting

Address 96 Marine Terrace, Walyalup (Fremantle), Western Australia 6160

Contact Mathew Oliver
Caring for Country Coordinator
Mat.oliver@trco.com.au

Report author Danika Penson

Report editor Mathew Oliver

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Version Control

Version	Date	Change log	Author(s)
1.0	2/11/22	Draft version 1.0	Danika Penson
2.0	17/11/22	Version 2.0	Danika Penson
2.1	21/2/23	Version 2.1 – MO edits	Danika Penson & Mat Oliver
2.2	24/2/23	Version 2.2 – JT and SM edits	Danika Penson & Mat Oliver

Quality Statement

PROJECT MANAGER
Mat Oliver
PREPARED BY
Danika Penson and Mat Oliver
REVIEWED BY
Jessica Taylor and Shae Small

TERRA ROSA CONSULTING.
96 Marine Terrace
Walyalup (Fremantle) WA 6160
TEL 1300 008 726