Baseline Monitoring of Rehabilitation Programs in Alcoa's Bauxite Mining Areas

Winter Survey

Prepared for: Alcoa of Australia Ltd

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EXECUTIVE SUMMARY

Alcoa of Australia Ltd (Alcoa) has operated bauxite mines at Huntly and Willowdale east of Pinjarra in Western Australian since the 1970s. Once mining sites are no longer required, then they are rehabilitated with native vegetation. Alcoa has committed to monitoring the extent to which there is a progression toward the re-establishment of vertebrate fauna assemblages in these rehabilitated areas like that in selected analogue sites.

This is a report on the results of the second monitoring program. The first survey was undertaken in January 2023, and the results of the January and June-July 2023 surveys are compared and discussed. Comment and recommendations are provided on how Alcoa might enhance its program of establishing near-natural vertebrate fauna assemblages in rehabilitated areas.

1. INTRODUCTION

1.1 BACKGROUND

Alcoa of Australia Ltd (Alcoa) operates the Huntly and Willowdale bauxite mines east of Pinjarra in Western Australian on mineral lease ML1SA. The Huntly mine was established in 1972 and is located near Dwellingup and supplies bauxite ore to the Kwinana and Pinjarra refineries, as well as other clients. The Huntly mine currently includes locations at Myara, McCoy and Karnet. The Willowdale mine was established in 1984 and is located near Wagerup and supplies bauxite ore to the Wagerup refinery, as well as other clients. The Willowdale mine currently includes locations at Larego, Orion and Arundel.

The primary objective of Alcoa's bauxite mine rehabilitation program is to return a self-sustaining jarrah forest ecosystem after mining. This includes re-establishing populations of all faunal groups and species in densities and distributions required for maintaining forest biodiversity and ecosystem function. To ensure this objective is met, Alcoa established a long-term fauna monitoring program in 1991. This program characterises and monitors the key fauna of the areas in which Alcoa operates and assesses the impact of mining on these species.

1.2 SUCCESSION

Grant (2006) indicated that Alcoa's objective for its rehabilitation programs was to establish self-sustaining jarrah forest ecosystems. Grant (2006) went on to indicate that '*restored native ecosystems may be different in structure to the surrounding native ecosystems, but there should be confidence that they will change with time along with, or toward the structure and composition of the surrounding area*' and '*should be capable of withstanding disturbances such as fire or grazing*'. It has been presumed that this object is still applicable.

Primary succession is defined here as a process of change in the species structure of an ecological community over time from an assemblage that commences on barren or highly disturbed land to the climax community. This can be diagrammatically represented as shown in Plate 1.

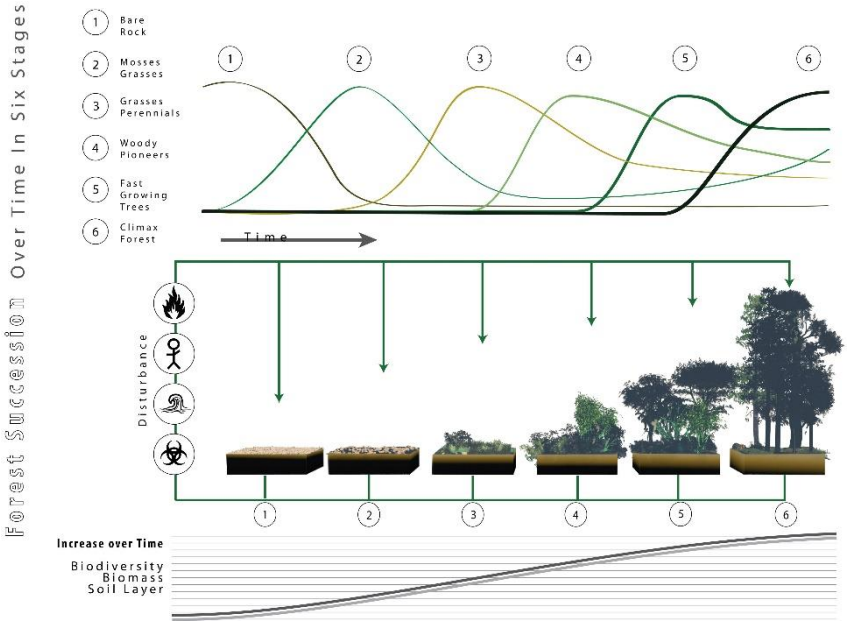


Plate 1. Conceptual diagram of primary succession

During the very early stages, very few terrestrial vertebrate species will colonise the area due to a lack of suitable habitat and there are likely to be higher levels of predation because of a lack of cover and retreat sites. Once the vegetation, invertebrates and microbial activity move through the succession stages and additional habitat niches become available, then more species can colonise the rehabilitated areas. In some cases, the abundance of early colonisers (i.e. pioneers) will be reduced due to competition and changing habitat conditions. Rehabilitated areas will cycle through many iterations of this process and along the way, species abundance typically increases, and the various species reach population levels suitable for the habitat and resources available, until such time it becomes a climax community.

Vertebrate fauna are only a part of the primary succession process and their progress from pioneering species toward a climax community is interrelated with the vegetation, fungi, microbial and invertebrate community development. Within broad boundaries, the trajectory in rehabilitated areas should be apparent in monitoring data (Plate 2).

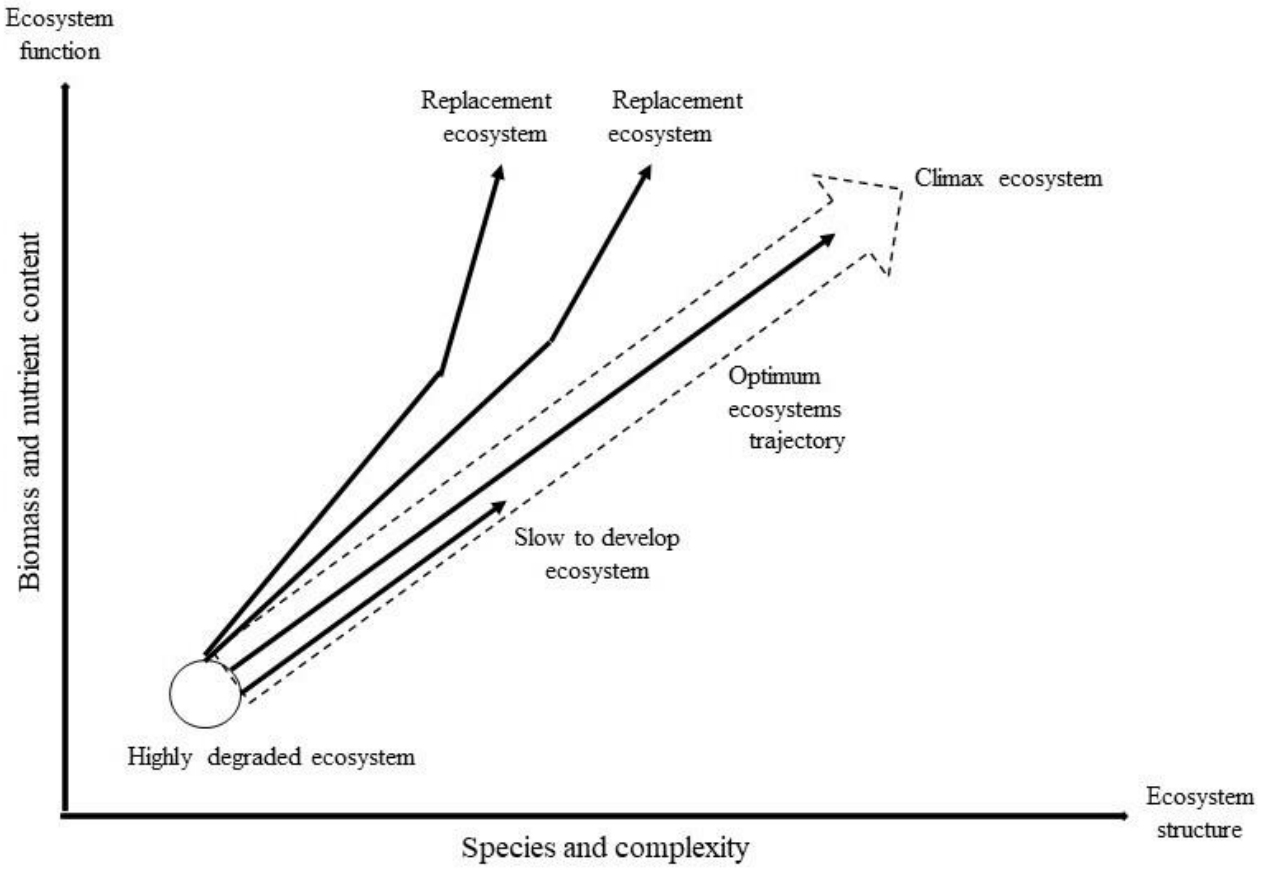


Plate 2. Primary succession trajectory(taken from: Bradshaw 1984)

Anderson et al. (2022) and Cross et al. (2019, 2021) argued that fauna have very often been forgotten in considering rehabilitation success with the focus on soils and vegetation. Anderson et al. (2022) went on to suggest a framework for incorporating fauna into the restoration process, and in doing so, identified the following five key criteria for effective faunal standards:

- appropriate reference ecosystem [analogue site(s)];
- faunal taxa to be considered;
- attributes of these taxa to be measured;
- acceptable level of similarity with reference conditions; and
- sampling methodology that is sufficiently robust to provide reliable comparative data.

1.3 OBJECTIVE

Alcoa's intention was to establish long-term monitoring sites for vertebrate fauna in unmined areas, and areas rehabilitated 5, 10 and 15-years ago. It was proposed that the vertebrate fauna at these sites would be periodically monitored to enable judgements to be made about the extent to which rehabilitated areas were progressing on a trajectory towards the recreation of functional ecosystems, like that in the unmined areas. Outcomes from these monitoring surveys would inform planning for future rehabilitated areas and where appropriate corrective action in existing rehabilitated areas.

Here we provide a description of the methods used to collect vertebrate fauna data, the results of the baseline monitoring program in winter, discussion of the results, a commentary on the program and a suggested way forward.

2. METHODS

The survey methodology adopted was identical to that implemented in the January 2023 monitoring survey.

2.1 PIT-TRAPPING PROGRAM

Twelve sites in the Jarrah Forest (Figures 1 and 2) were established by Alcoa (Plates 21-44). This included three unmined analogue sites, three sites that were rehabilitated in 2007 (i.e. 15-years old), three sites that were rehabilitated in 2012 (i.e. 10-years old) and three sites that were rehabilitated in 2017 (i.e. 5-years old).

At each site there were four near parallel drift fences 30m long with approximately 25cm of flywire above the ground. Along each drift fence there were three 20L PVC buckets, three PVC 150mm diameter pipes that were 400mm deep (Plate 4) and buried mid-line along the flywire drift fence. Three pair of funnels traps were deployed either side of the drift fence and three aluminium box traps were set approximately 10m to the side of the drift fence (Plate 5). Buckets used as pit-traps had holes and styrene sheets in the bottom to provide captured fauna protection from unfavourable environmental conditions. These traps targeted small mammals, reptiles and amphibians.

The location of trapping sites is shown in Figures 2-14 and the coordinates are provided in Appendix B. Traps were opened on 27 June and closed on 9 July 2023.

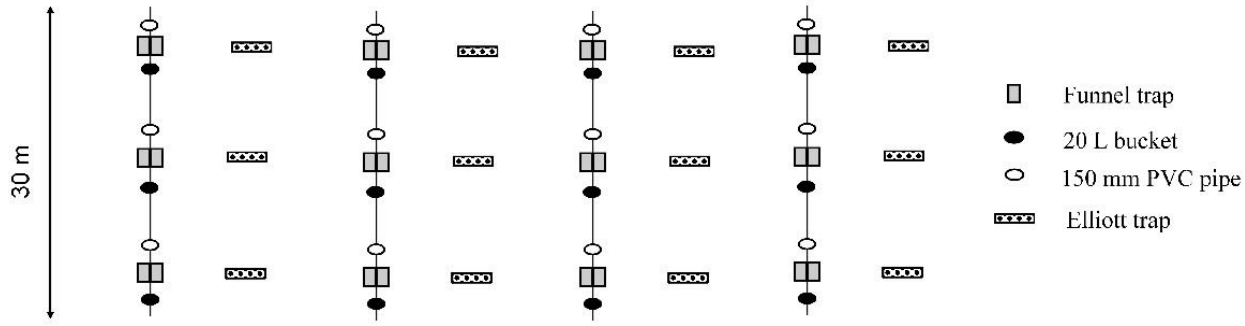


Plate 3. Trapping site layout



Plate 4. Pit-fall trap on a drift fence



Plate 5. Pair of funnel traps on a drift fence

2.2 CAGE TRAPPING PROGRAM

Eighty cage traps (Plate 6) targeting Chuditch (*Dasyurus geoffroii*) were deployed adjacent to gravel tracks where Alcoa believed that there may have been Chuditch. Trapping sites were selected by Alcoa on the basis that some were inside the mining area and comprised a variety of levels of disturbance (i.e. rehabilitation of various ages and remnant vegetation), and the others were outside the mine perimeter in unmined forest (Figures 18-21).

Cage traps were baited with raw chicken necks which were replaced every three days or as required. Cage traps were set up on 26 June and removed on 8 July 2023.



Plate 6. Baited cage trap

2.3 CAMERA TRAPS

Camera traps targeted the medium and large mammals, but any fauna recorded were reported.

Twenty-four camera traps (Reconyx HC600) were deployed in the denser vegetation targeting Quokka (*Setonix brachyurus*) and Quenda (*Isoodon fusciventer*; Figures 15-17). Each camera trap had a non-reward lure (Plate 7) placed ~3-4m in front of the camera trap (Plate 8) in the detection zone. Lures were a mixture of peanut butter, rolled oats and sardines topped up with mullie oil. Camera traps were deployed on 26 June and retrieved on 8 July 2023.



Plate 7. Non-reward lure



Plate 8. Mounted camera trap

2.4 INVERTEBRATE SAMPLING

Each trapping site was searched for invertebrates for one hour by two people for the following taxonomic groups: isopods, diplopods, opiliones, scorpions, mygalomorph spiders and pseudoscorpions. Specimens were preserved in ethanol but not identified. In addition, specimens from these taxonomic groups caught in pit and funnel traps were also collected and preserved. All specimens were given to Alcoa for identification and analysis.

2.5 DATA ANALYSIS

There were insufficient individual animals caught at the trapping sites to undertake any meaningful analysis. Some comparisons between what was caught and recorded in the January and July 2023 surveys has been provided in the discussion. All animal identifications were done by field staff.

2.6 STAFF

The field work was undertaken by Dr James Barr, Tom Raymond, Brody Altus, Stelleena Mackay, Mitch Plozza and Isaac Cable. Dr Graham Thompson drafted the report and it was reviewed by Dr Scott Thompson before being submitted to Alcoa for comment and review. As an EIANZ Certified Environmental Practitioner [CEnvP (Ecology Specialist)], Scott is appropriately qualified to sign off on the final report.

3. RESULTS

3.1 WEATHER

Compared with the January 2023 survey period, the June-July trapping was much cooler (Table 1). There was only one day of very light rain in January, whereas it rained on 12 days during the June-July survey period, although rain was light on many days.

Table 1. Weather data for the January and the June-July surveys (BOM ID 94620 Dwellingup)

Date	Min. T°	Max. T°	Max. rainfall	Date	Min. T°	Max. T°	Max. rainfall
7/1/2023	12.6	27.1	0	25/6/2023	6.2	11.9	4.4
8/1/2023	12.4	30.8	0	26/6/2023	3	12.9	0.2
9/1/2023	14.3	36.5	0	27/6/2023	-0.9	15.2	0
10/1/2023	18.9	35.5	0.8	28/6/2023	2.1	14.0	0.2
11/1/2023	17.1	29.1	0	29/6/2023	1	14.8	0
12/1/2023	13.6	31.9	0	30/6/2023	-0.2	15.0	0
13/1/2023	13.8	27.5	0	1/7/2023	-0.1	15.8	0.2
14/1/2023	11.9	28.5	0	2/7/2023	0.8	16.9	0.2
15/1/2023	11.5	31.8	0	3/7/2023	6	15.4	6.4
16/1/2023	13.4	25.2	0	4/7/2023	7.5	12.7	37.0
17/1/2023	9.8	26.6	0	5/7/2023	7.7	12.7	17.8
18/1/2023	11.9	30.0	0	6/7/2023	6.2	14.6	2.8
19/1/2023	13.1	33.8	0	7/7/2023	9.1	15.6	5.0
20/1/2023	16.2	35.5	0	8/7/2023	7.8	17.0	5.2
21/1/2023	18.8	38	0	9/7/2023	8.5	16.9	0.2

3.2 TRAPPING RESULTS

The location of trapping sites is shown in Figures 1-21 in the appendices. All vertebrate fauna caught in pit, funnel and aluminium box traps are shown in Table 2.

Table 2. Trapping data results

		Survey site status	Unmined	Unmined	Unmined	15-year rehabilitation	15-year rehabilitation	15-year rehabilitation	10-year rehabilitation	10-year rehabilitation	10-year rehabilitation	5-year rehabilitation	5-year rehabilitation	5-year rehabilitation	Total
Taxa	**Family**	**Species** **Survey sites**	**1**	**2**	**3**	**7**	**8**	**12**	**4**	**5**	**6**	**9**	**10**	**11**	
Frogs	Myobatrachidae	*Crinia georgiana*		9	5		7		8	8	4	36	26	6	109
		Crinia insignifera											1		1
	Pelodryadidae	*Litoria adelaidensis*											1		1
Mammals	Dasyuridae	*Antechinus flavipes*	4	11	2		3	8	2	1	6				37
		Sminthopsis sp.	2						1				1	1	5
	Burramyidae	*Cercartetus concinnus*									1				1
	Muridae	*Mus musculus*				1							2	1	4
Reptiles	Scincidae	*Cryptoblepharus buchananii*											1		1

We are unsure of the identity of the *Sminthopsis* spp. and an individual has been lodged with the Western Australian Museum for identification.

3.3 CAGE TRAP RESULTS

Vertebrate fauna caught in cage traps are shown in Table 3.

Table 3. Fauna caught in a cage traps

			Trap numbers																						
			Unmined	Reh. 2004	Reh. 2004	Reh. 2005	Unmined	Unmined	Unmined	Reh. 2005	Reh. 2001	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined
Taxa	**Family**	**Species**	**18C**	**42C**	**43C**	**45C**	**47C**	**48C**	**49C**	**50C**	**52C**	**53C**	**54C**	**5C**	**60C**	**67C**	**68C**	**69C**	**70C**	**72C**	**73C**	**76C**	**77C**	**78C**
Mammals	Dasyuridae	*Dasyurus geoffroii*	1	3	6	1	2	1	2	2	4		1		1	1		1	1	1	2	1	1	1
	Tachyglossidae	*Tachyglossus aculeatus*										1		2										
	Peramelidae	*Isoodon fusciventer*									1						1							

Thirteen of the 17 female (33 in total) Chuditch had 3-5 pouch young and one Chuditch was a recapture.



Plate 9. Echidna



Plate 10. Buchanan's Snake-eyed Skink



Plate 11. Dunnart



Plate 12. Chuditch pouch young



Plate 13. Releasing a Chuditch



Plate 14. Chuditch in a trap

3.4 RESULTS BY TRAP TYPE

Vertebrate fauna caught by trap type are shown in Table 4.

Table 4. Vertebrate fauna recorded by trap type

Taxa	Family	Species	Aluminium box trap	Bucket pit trap	Cage trap	Funnel	Pipe pit trap
Frogs	Myobatrachidae	*Crinia georgiana*		70		9	30
	Pelodryadidae	*Litoria adelaidensis*				1	
Mammals	Dasyuridae	*Antechinus flavipes*	30	3		1	3
		Dasyurus geoffroii			33		
		Sminthopsis sp.		1			4
	Burramyidae	*Cercartetus concinnus*					1
	Tachyglossidae	*Tachyglossus aculeatus*			3		
	Peramelidae	*Isoodon fusciventer*			2		
	Muridae	*Mus musculus*	1	1			2

Taxa	Family	Species	Aluminium box trap	Bucket pit trap	Cage trap	Funnel	Pipe pit trap
Reptiles	Scincidae	*Cryptoblepharus buchananii*					1
Total			31	75	38	11	41

3.5 CAMERA TRAPPING RESULTS

Vertebrate fauna recorded by camera traps are shown in Table 5.

Table 5. Camera trap results

			Camera trap numbers																							
			Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined	Unmined
Taxa	Family	Species	CM1	CM2	CM3	CM4	CM5	CM6	CM7	CM8	CM9	CM10	CM11	CM12	CM13	CM14	CM15	CM16	CM17	CM18	CM19	CM20	CM21	CM22	CM23	CM24
Bird	Alcedinidae	*Dacelo novaeguineae**																								1
	Acanthizidae	*Sericornis frontalis*	1	2		1	2	1		1	2															
	Maluridae	*Malurus elegans*	1	2		1	2	1	1	3						1										
		Malurus sp.													3											
		Malurus splendens													1											
	Pachycephalidae	*Pachycephala pectoralis*										1														
	Rhipiduridae	*Rhipidura albiscapa*		2			1					1														
Mammals	Suidae	*Sus scrofa**											1					1								
	Dasyuridae	*Antechinus flavipes*		1	1	1	2	2	2	1				1	2	1	1									1
		Dasyurus geoffroii									1	2	1	1	1	1		2								
		Sminthopsis sp.			1																					
	Macropodidae	*Macropus fuliginosus*																		1			1			
		Setonix brachyurus										3	2	2	2	3										
	Peramelidae	*Isoodon fusciventer*									2	2	2	2	2	2		1		1	1	1	1	1		2
	Muridae	*Mus musculus**	1	1		1	1						1		1	2	1	1			1		1	1		
		*Rattus rattus**	1	2	1	2	1	2	1	1											1		1	1	1	

* non-native species

One Fairywren was unable to be identified, and as indicated above, the *Sminthopsis* spp. has been lodged with the Western Australian Museum for identification.



Plate 15. Chuditch



Plate 16. Quenda



Plate 17. Black Rats



Plate 18. Quokkas



Plate 19. Quokka



Plate 20. Pig

In addition, two *Hemiergis initialis* were observed near trapping site 3, and a *Crinia insignifera* near trapping site 10 during the collection of invertebrates, and *Notamacropus irma* were recorded between cages 68-69, two *Sus scrofa* were recorded between trapping sites 3 and 4, and another was recorded crossing the road near the entry to Alcoa Myara mine site.

4. DISCUSSION

4.1 PIT, FUNNEL AND ALUMINIUM BOX TRAPS

The pit, funnel and aluminium box trapping program predominantly caught frogs in the June-July 2023 survey period, and in particular *Crinia georgiana* (Quacking Frog), and most of these captures were in the rehabilitation sites. Many fewer frogs were caught during the January 2023 survey period, which was expected because it was hotter and there had been much less rain in the summer period.

Forty- nine *Antechinus flavipes* (Yellow-footed Antechinus) were caught in the January survey compared to 37 in the June-July survey, which was similar, but 66 *Cercartetus concinnus* (Western Pygmy Possum) were caught in the January survey compared with one in the June-July survey period. Thompson (2004) similarly recorded large variations in the capture of *C. concinnus* in pit-traps in the Goldfields, and this is probably due to the abundance of nectar producing plants that are flowering at the time and the ambient temperature. In cold weather, *C. concinnus* enters torpor and if found it is typically curled up in a ball and immobile. Based on the data recorded in the January 2023 survey, these pygmy possums are present in most of the survey sites, but the June-July survey indicates that they are only caught when they move around.

Antechinus flavipes was predominantly caught in the older rehabilitated areas and unmined area in both the January and June-July surveys. This species is probably one of the early colonisers, as it is a mobile and a widely foraging dasyurid.

The capture of a single reptile in the trapping program (i.e. *Cryptoblepharus buchananii*; Buchanan's Snake-eyed Skink) is typical of what occurs in cold weather, as most of the small reptiles that warm up quickly and are active during winter have very small home ranges and therefore are less likely to be trapped, and the larger reptiles are generally inactive and therefore not caught.

Like the January survey, most of the *Mus musculus* (House Mouse) caught in the June-July survey were in the more recent rehabilitation areas being mobile and early colonisers (Thompson and Thompson 2007).

Overall, there was insufficient data to draw any conclusions about patterns of succession from the pit, funnel and aluminium box trapping data.

Table 6. Comparison of trapping results for the January and June-July 2023 surveys

		Survey site status	Unmined		Unmined		Unmined		15-year rehabilitation		15-year rehabilitation		15-year rehabilitation		10-year rehabilitation		10-year rehabilitation		10-year rehabilitation		5-year rehabilitation		5-year rehabilitation		5-year rehabilitation		Total	
Taxa	**Family**	**Species** **Survey sites**	**1**		**2**		**3**		**7**		**8**		**12**		**4**		**5**		**6**		**9**		**10**		**11**			
			Jan	Jul	Jan	Jul	Jan	Jul	Jan	Jul	Jan	Jul	Jan	Jul	Jan	Jul	Jan	Jul	Jan	Jul	Jan	Jul	Jan	Jul	Jan	Jul	Jan	Jul
Amphibian	Limnodynastidae	*Heleioporus eyrei*					2																				2	
		Heleioporus inornatus	1																								1	
	Myobatrachidae	*Crinia georgiana*			2	9		5				7			1	8		8		4	1	36		26		6	4	109
		Crinea insignifera																						1				1
	Pelodryadidae	*Litoria adelaidensis*																						1				1
Mammal	Burramyidae	*Cercartetus concinnus*	3		2		1		23		13		8		3				12	1					1		66	1
	Dasyuridae	*Antechinus flavipes*		4	1	11	14	2	5		1	3	4	8	11	2	7	1	2	6	2		2				49	37
		Sminthopsis gilberti					1		2		1		2		5				1		2		1		2		17	
		Sminthopsis sp.		2												2								1		1		
	Muridae	*Mus musculus*								1							1		1		6			2	5	1	13	4
Reptile	Agamidae	*Pogona minor*							3		1						2		2						1		9	
	Carphodactylidae	*Underwoodisaurus milii*	2		2												2				1		3		3		13	
	Diplodactylidae	*Diplodactylus lateroides*			1				1		1								1		2		6		1		13	
		Diplodactylus polyophthalmus							1						1										1		3	
	Elapidae	*Suta gouldii*							1										1								2	

		Survey site status	Unmined		Unmined		Unmined		15-year rehabilitation		15-year rehabilitation		15-year rehabilitation		10-year rehabilitation		10-year rehabilitation		10-year rehabilitation		5-year rehabilitation		5-year rehabilitation		5-year rehabilitation		Total	
		Suta nigriceps	1														3										4	
	Gekkonidae	*Christinus marmoratus*																							1		1	
	Pygopodidae	*Lialis burtonis*																	1								1	
	Scincidae	*Acritoscincus trilineatus*			7		2		9		6		9		1		12		9				1		3		59	
		Cryptoblepharus buchananii	3		7		2														1			1			13	1
		Egernia napoleonis	13		5		1										1										20	
		Hemiergis initialis	2		4						2		2				5										15	
		Lerista distinguenda	11		15		11		3		4						3		6		1						54	
		Lerista elegans			1				1								3										5	
		Menetia greyii	3				1		4		4				2		1		3		1		6		7		32	
		Morethia obscura	14		13		2		7		7		4		4		6		9		9		1		4		80	
		Tiliqua rugosa									1																1	
	Typhlopidae	*Anilios australis*			5						1						1		1								8	

4.2 CAGE TRAPS

Many more *D. geoffroii* (Chuditch) were caught in June-July (i.e. 33) than January 2023 (i.e. 12). Pouch young (i.e. 3-5) were present in 13 of the 17 females caught. If conditions were suitable, and most of the pouched young survived to join the adult population, then there would be a doubling of the population.

The number of *Isoodon fusciventer* (Quenda) caught in cage traps was the same for both survey periods (i.e. 2), with three *Tachyglossus aculeatus* (Echidna) being caught in the June-July survey and one in the January survey.

4.3 CAMERA TRAPS

Many more *Sus scrofa* (feral pigs) were recorded during the January survey than the June-July survey. This variability is almost certainly due to the pigs mobility and preference for wetter areas. In the summer months the pigs might prefer the cooler wetter creek areas but disperse more widely during winter as the wetter areas are more common. As was the case for the cage trapping program, many more *D. geoffroii* were recorded in the June-July period compared with the January period. The copulating period for *D. geoffroii* had mostly finished and it might be expected that there would be a die-off of the adult male cohort before summer.

Of interest is the huge variation in the number of *Macropus fuliginosus* (Western Grey Kangaroo) recorded by camera traps, with two recorded in the June-July survey and 24 in the January survey. *Macropus fuliginosus* is patchy and obviously moves around the Jarrah forest, and the same is probably true for *Notamacropus irma* (Western Brush Wallaby) which were recorded on camera traps in January and not at all in the June-July survey period. These macropods may also favour the cooler wetter environments which were the targeted areas for camera trapping and spatially restricted in summer.

Many more *I. fusciventer* were recorded in the June-July (i.e. 20) survey than in the January (i.e. 5) survey, and there is a similar pattern for *Setonix brachyurus* (Quokka) with 12 recorded in the June-July survey and six recorded in the January survey. As with the larger macropods (e.g. *M. fuliginosus*) both of these mammals are quite mobile, and camera trapping surveys can indicate presence, but unless there is a specific method of identifying individuals (i.e. body fur pattern), then they are not a good measure of abundance.

4.4 WINTER VS SUMMER SURVEY

Ambient weather conditions had a notable impact on the surface activity of reptiles, with many fewer reptiles recorded during the cooler months than during the summer. This pattern was expected as it is also evident at other localities such as the Goldfields (Thompson 2004, Thompson and Thompson 2005). Many mammal species activity patterns are less affected by weather so there is less temporal variation in the trapping data, but species that enter torpor (e.g. *C. concinnus*) can be less active during the cold weather, and are therefore less likely to be trapped.

4.5 SPATIAL AND TEMPORAL VARIATIONS

One of the most significant outcomes of the comparison of two monitoring surveys undertaken (i.e. January and June-July 2023) is the appreciable spatial and temporal variation in the vertebrate fauna assemblage (see species and abundance variation in Table 6). The PCAs for the January survey (Charts 1 and 2) indicate appreciable variability within trapping sites for the unmined and the three categories of rehabilitation. If there was sufficient data for the June-July survey (which there isn't), then a similar spread among PCA scores for similar aged habitats is also likely to be recorded. This indicates the degree of spatial variability.

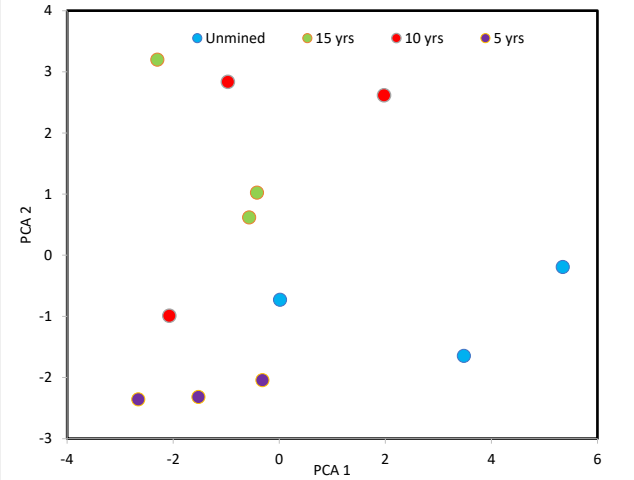


Chart 1. PCAs 1 and 2

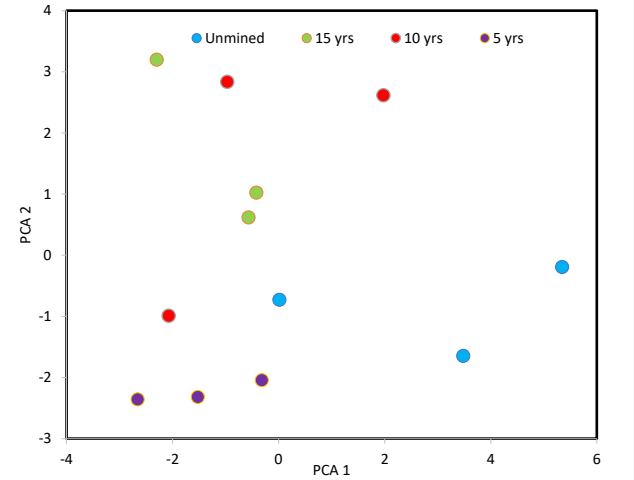


Chart 2. PCAs 1 and 3

Differences in the vertebrate fauna assemblage recorded using pit and funnel traps, cage traps and camera traps between the January and June-July surveys indicate very notable differences (see Table 6). Many of these differences are to be expected because of the variation in weather conditions (e.g. low reptile numbers during the winter survey period) and the mobility of species (e.g. camera trapping records for *M. fuliginosus* and *N. irma*). Therefore, comparison among capture records for different survey periods of the year are likely to provide spurious results if used for the purposes of monitoring succession over numerous years. However, it was not Alcoa's intention to compare the summer and winter results, rather to get a better appreciation of the vertebrate species in the various areas.

4.6 COMMENT

The high-level objective of these monitoring surveys is to mitigate potential impacts of bauxite mining on the vertebrate fauna in the northern Jarrah forest. Measuring outcomes of rehabilitation programs is an important part of this process, as it enables Alcoa to amend and fine-tune its rehabilitation programs, and to indicate to the environmental regulators and other stakeholders the success or otherwise of its rehabilitation programs in recreating self-sustaining, functional ecosystems.

Based on the data accumulated during the January 2023 survey, the current monitoring program requires adjustment, as the analogue sites for the rehabilitated areas appear not to be appropriate given the spatial variability in the vertebrate fauna assemblages in the unmined, and possibly older rehabilitated sites of the northern Jarrah forest. Given that it is the fauna assemblages in the unmined areas adjacent to the rehabilitated sites that are the primary source populations for the colonising fauna species in the rehabilitated areas, analogue survey sites should be near these areas. This will obviously require new survey sites to be established.

Many of the vertebrate fauna caught and recorded in the monitoring program are common, widespread and abundant, and given the mosaic disturbance pattern undertaken by Alcoa to mine bauxite in the northern Jarrah forest, the mining program is unlikely to threaten any of these common species. However, the northern Jarrah forest mining area is home to numerous threatened species (i.e. *S. brachyurus*, *D. geoffroii*, *I. fusciventer* and *N. irma*) and also home to a few feral vertebrate pest species (*Vulpes vulpes* (fox), *Felis catus* (cat), *S. scrofa*, *Rattus rattus* (Black Rat) and *M. musculus*). The fox is a known serious predator of *S. brachyurus*, *D. geoffroii* and *I. fusciventer* and the pigs are destroying habitat and ecosystems that that are crucial to the survival of these same species. Other than anecdotal information, little is known about the spatial distribution of *S. brachyurus*, *D. geoffroii*, *I. fusciventer, V. vulpes* and *S. scrofa* in the northern Jarrah forest areas mined by Alcoa. It is suggested that Alcoa focus on increasing the local population of threatened species and a reduction in the feral predators, as this will also have positive outcomes for the other native fauna in the Jarrah forest.

The camera and cage trapping program in June-July 2023 provided useful information about the abundance of these threatened species in selected areas, but the pit, funnel and aluminium box trapping program caught too few animals to be a useful monitoring tool.

The cage trapping programs targeted *D. geoffroii*, and they were also recorded in the camera trapping program. Cage trapping involves a stress on the animals, and it should therefore be avoided unless there is no other alternative to obtaining the same robust data. In this situation, camera traps can record the presence of Chuditch, and given that they have a unique spot pattern, most can be individually identified and therefore a cage trapping program would not be required. A few Quenda were caught in the cage trapping program, but the bait used was not very suitable for this species; Quenda were also recorded on camera traps. It is therefore suggested that cage traps are not used in future trapping programs, and an individual Chuditch identification program is used in its place based on a broader camera trapping network.

4.7 RECOMMENDATIONS

It is recommended that:

- the analogue sites for the rehabilitation areas be relocated to the unmined areas adjacent to the rehabilitated areas that are being monitored;
- the summer (i.e. January) surveys are used in the monitoring of rehabilitated and unmined areas only using pit, funnel and aluminium box traps;
- a program is developed to increase the population of *S. brachyurus*, *D. geoffroii* and *I. fusciventer* in mining areas, and in rehabilitated areas. This program will initially focus on identifying the location and abundance of these species and areas of *V. vulpes* and *S. scrofa* activity with a view to developing a long-term conservation plan that will increase the population of these threatened species; and
- the cage trapping program targeting Chuditch be replaced with camera trapping and a spot recognition analysis to determine relative abundance across the areas.

5. REFERENCES

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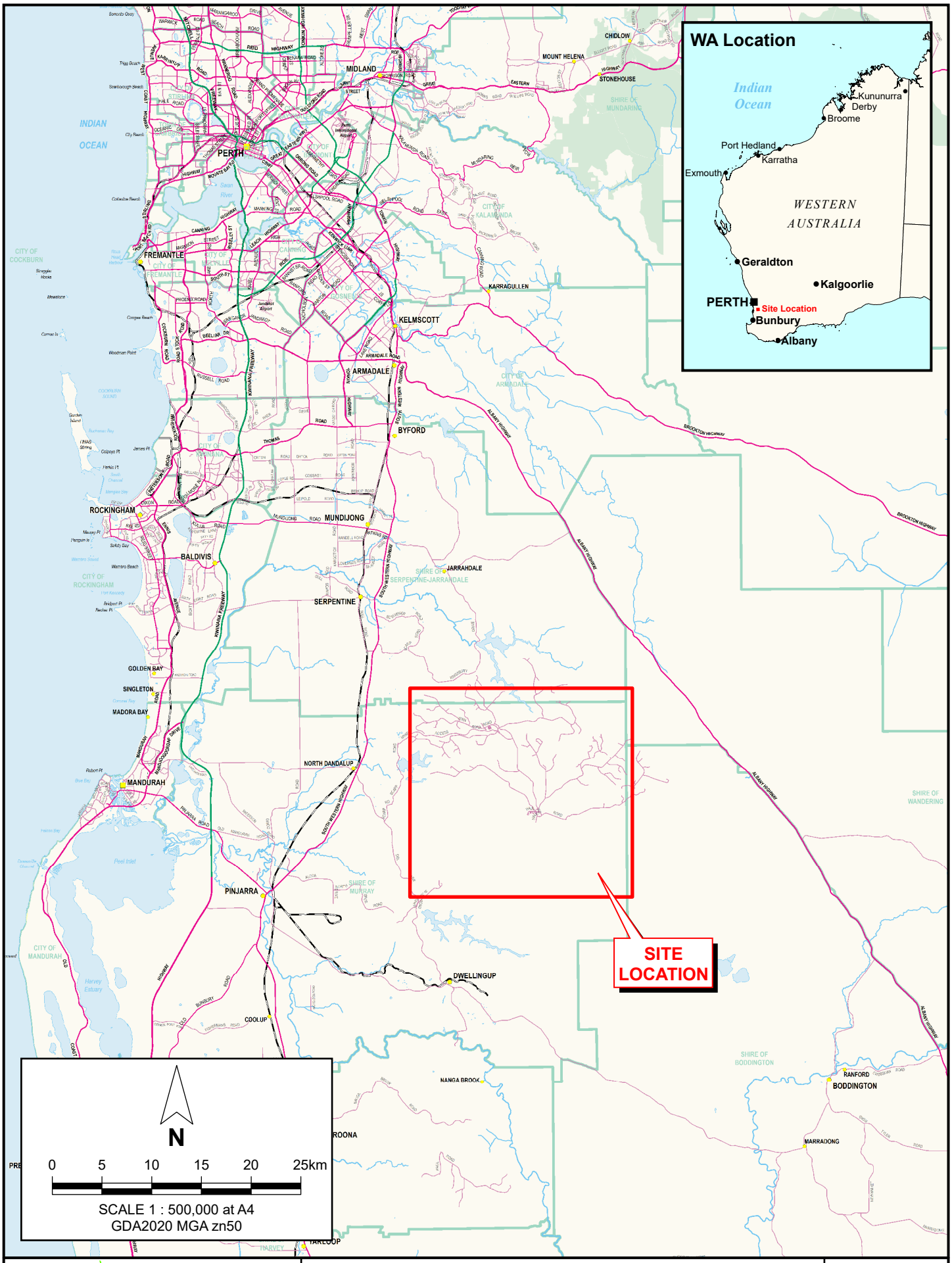
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Figures

Baseline Monitoring of Rehabilitation Programs in Alcoa's Bauxite Mining Areas
Winter Survey





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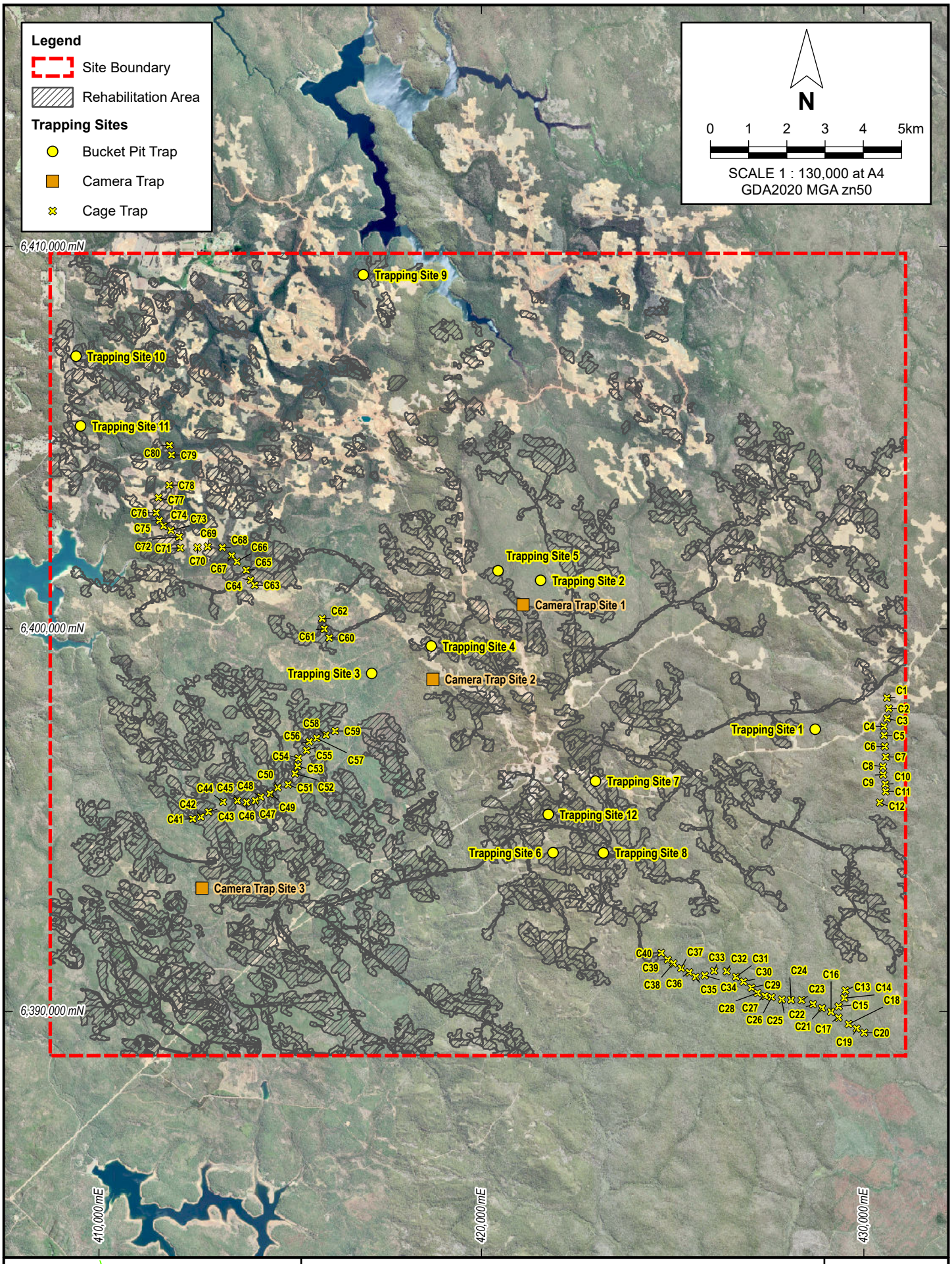
TERRESTRIAL ECOSYSTEMS

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BASELINE MONITORING SURVEY OF REHABILITATION PROGRAMS IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

Figure 1

REGIONAL LOCATION

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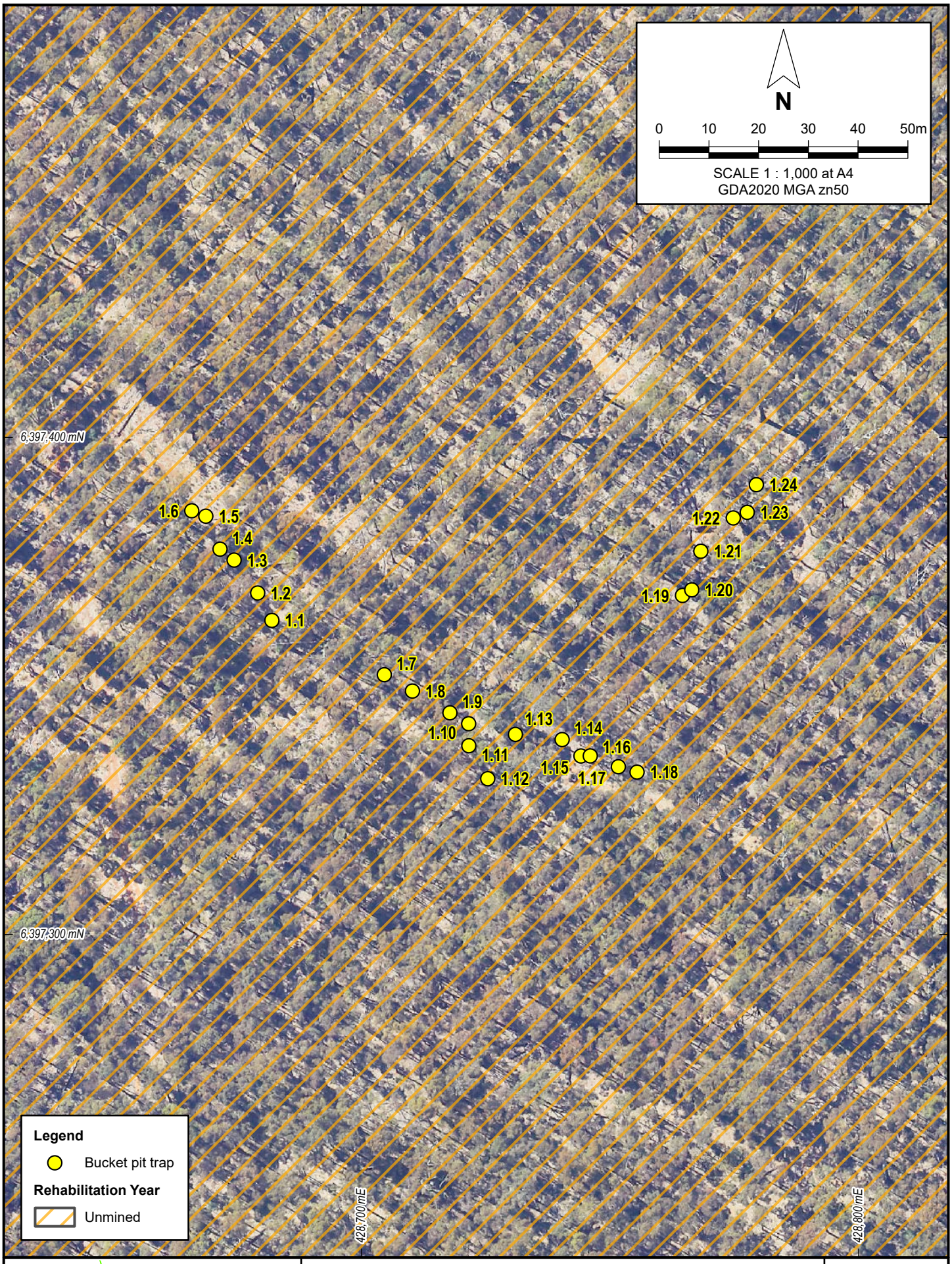
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BASELINE MONITORING SURVEY OF REHABILITATION PROGRAMS IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

PROJECT AREA

Figure 2

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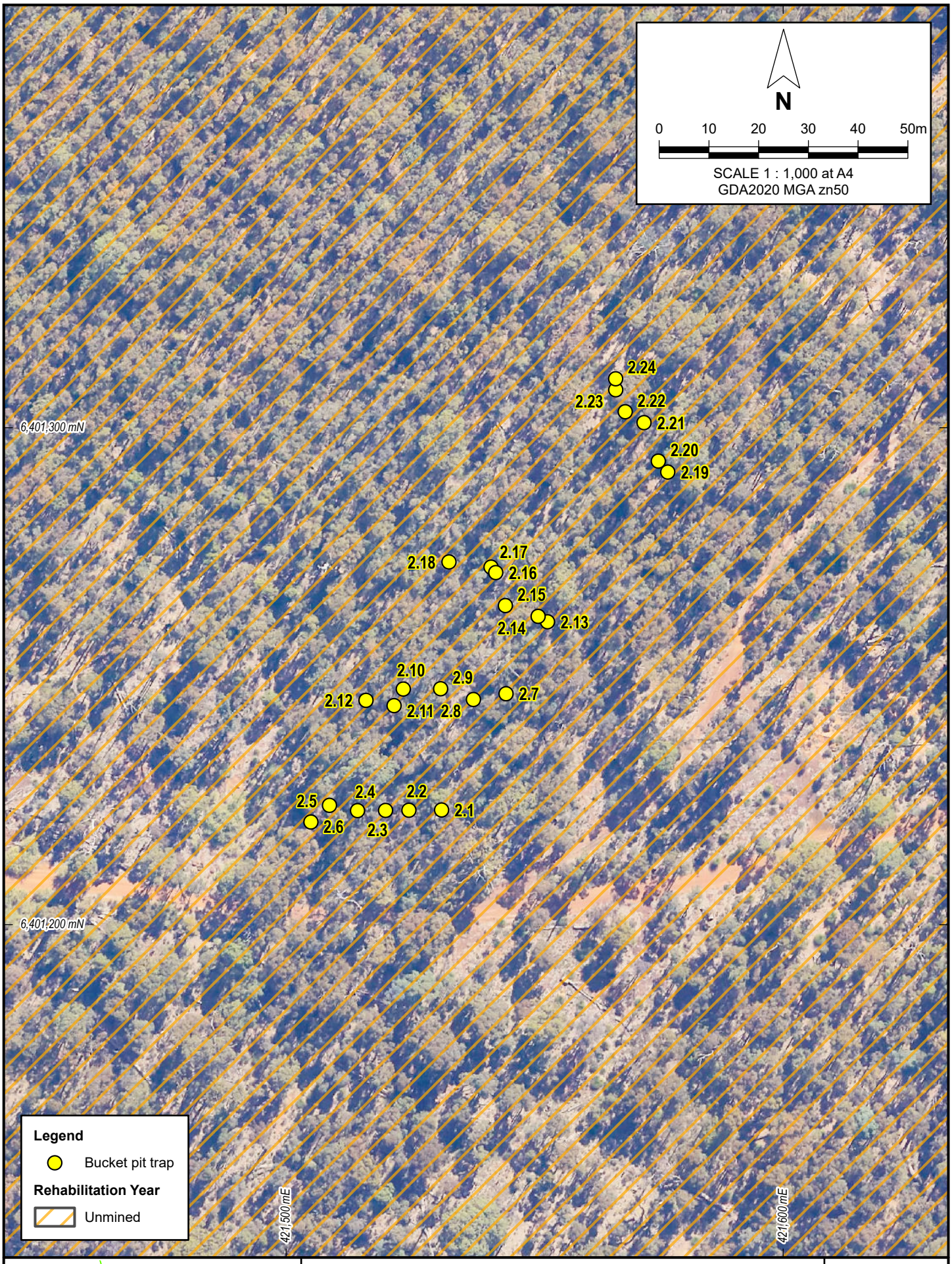
TERRESTRIAL ECOSYSTEMS

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IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

Figure 3

PIT TRAP LOCATIONS - TRAP SITE 1

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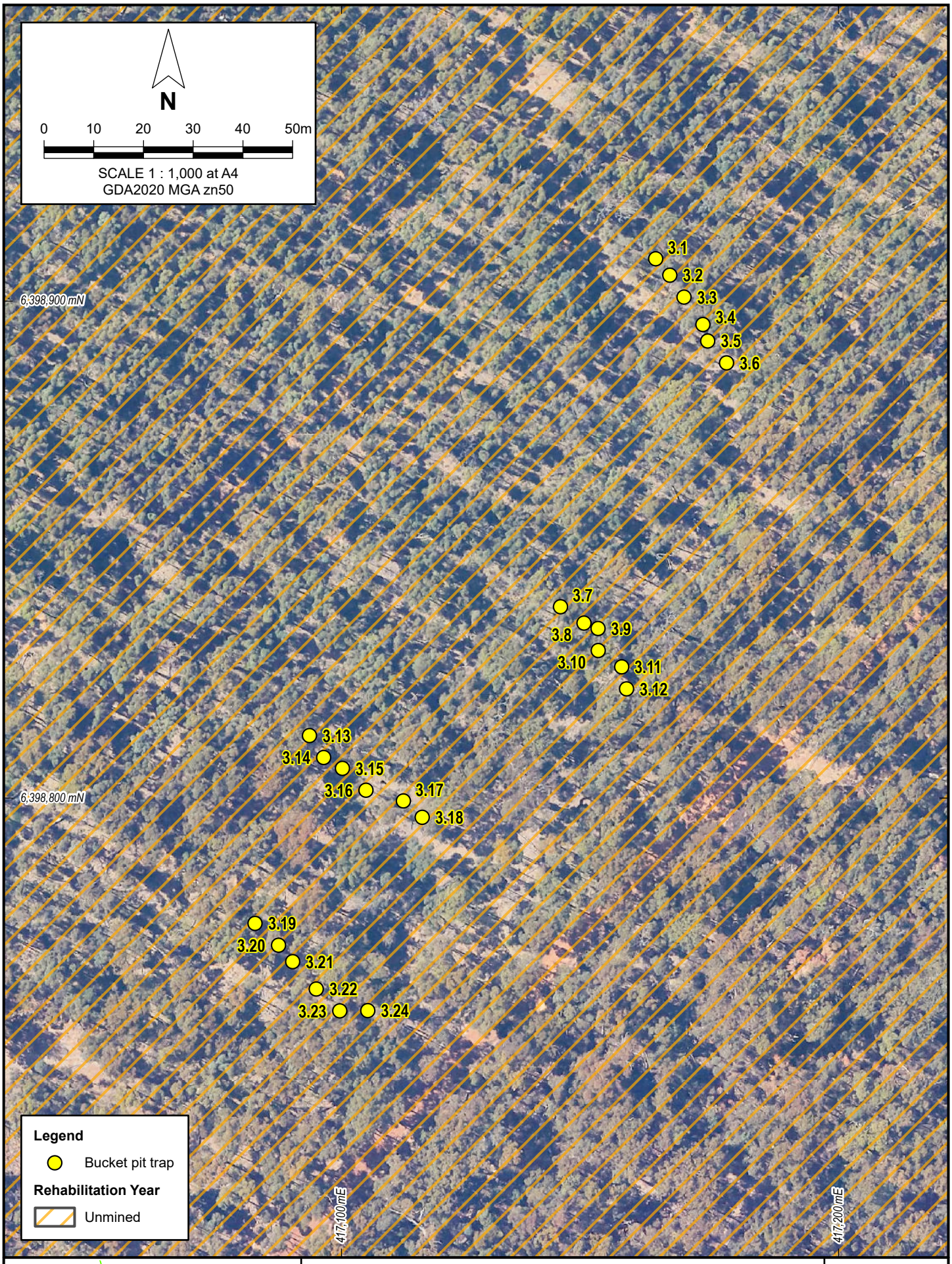
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PIT TRAP LOCATIONS - TRAP SITE 2

Figure 4

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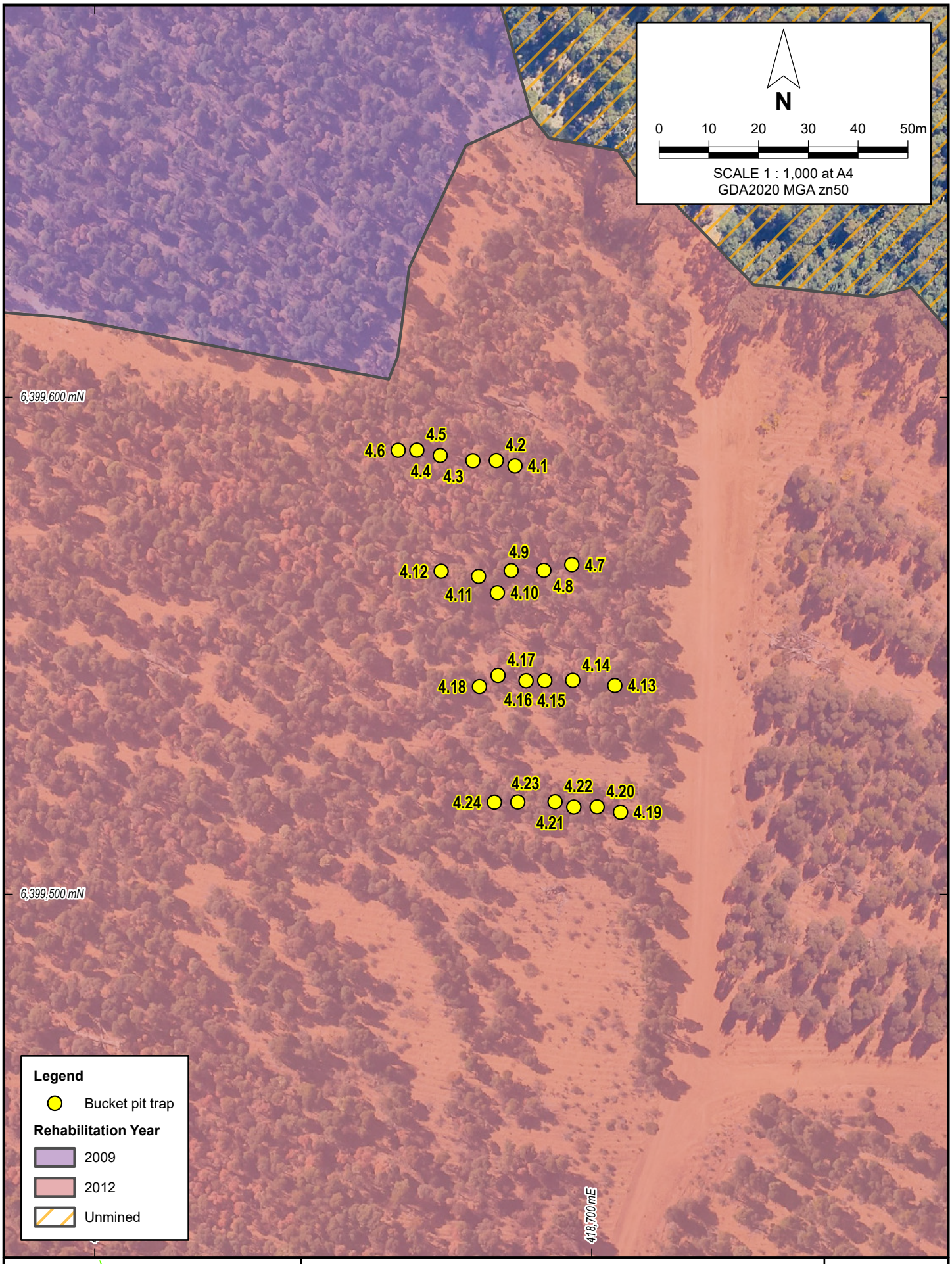
TERRESTRIAL ECOSYSTEMS

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Figure 5

PIT TRAP LOCATIONS - TRAP SITE 3

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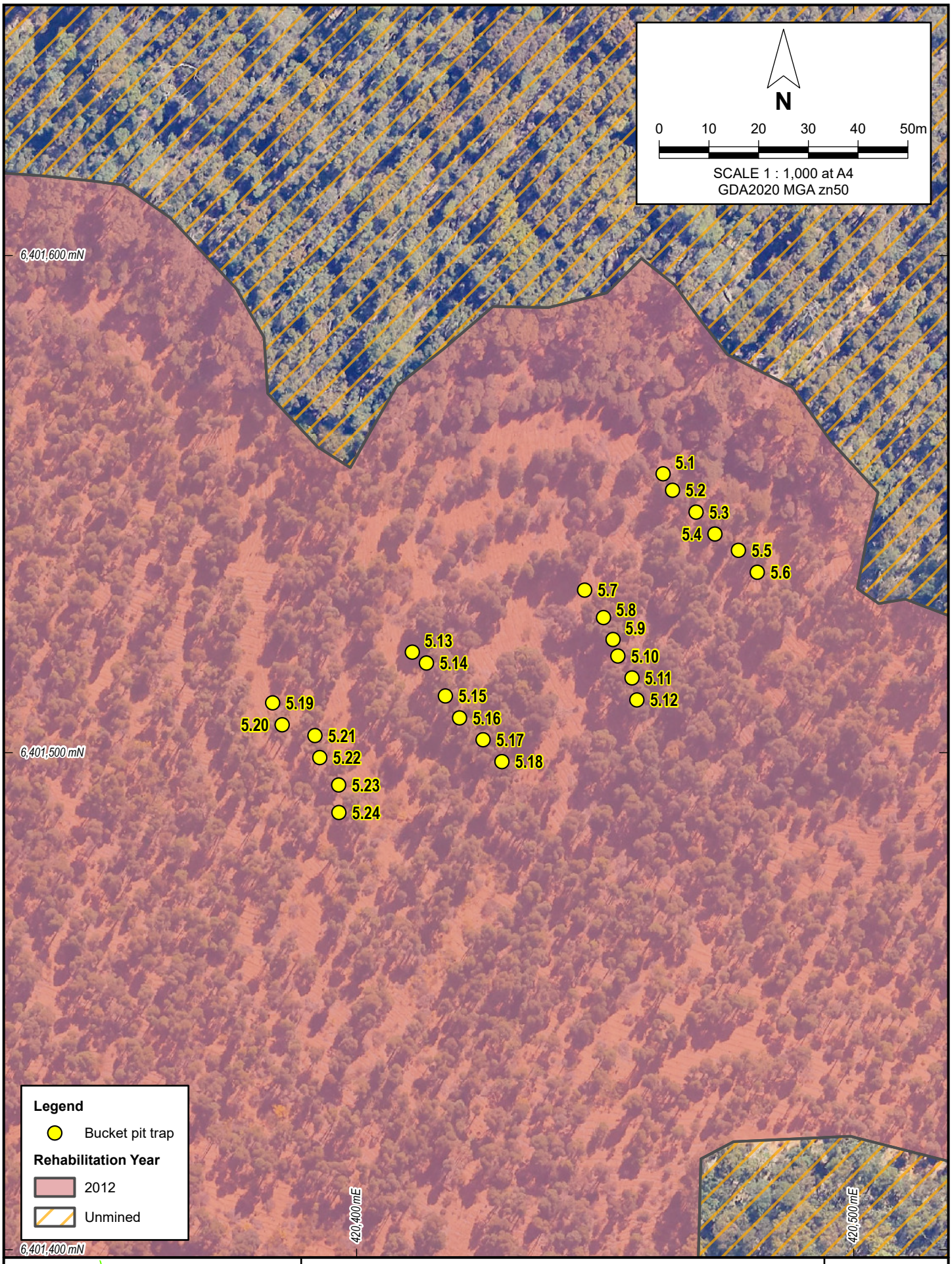
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Figure 6

PIT TRAP LOCATIONS - TRAP SITE 4

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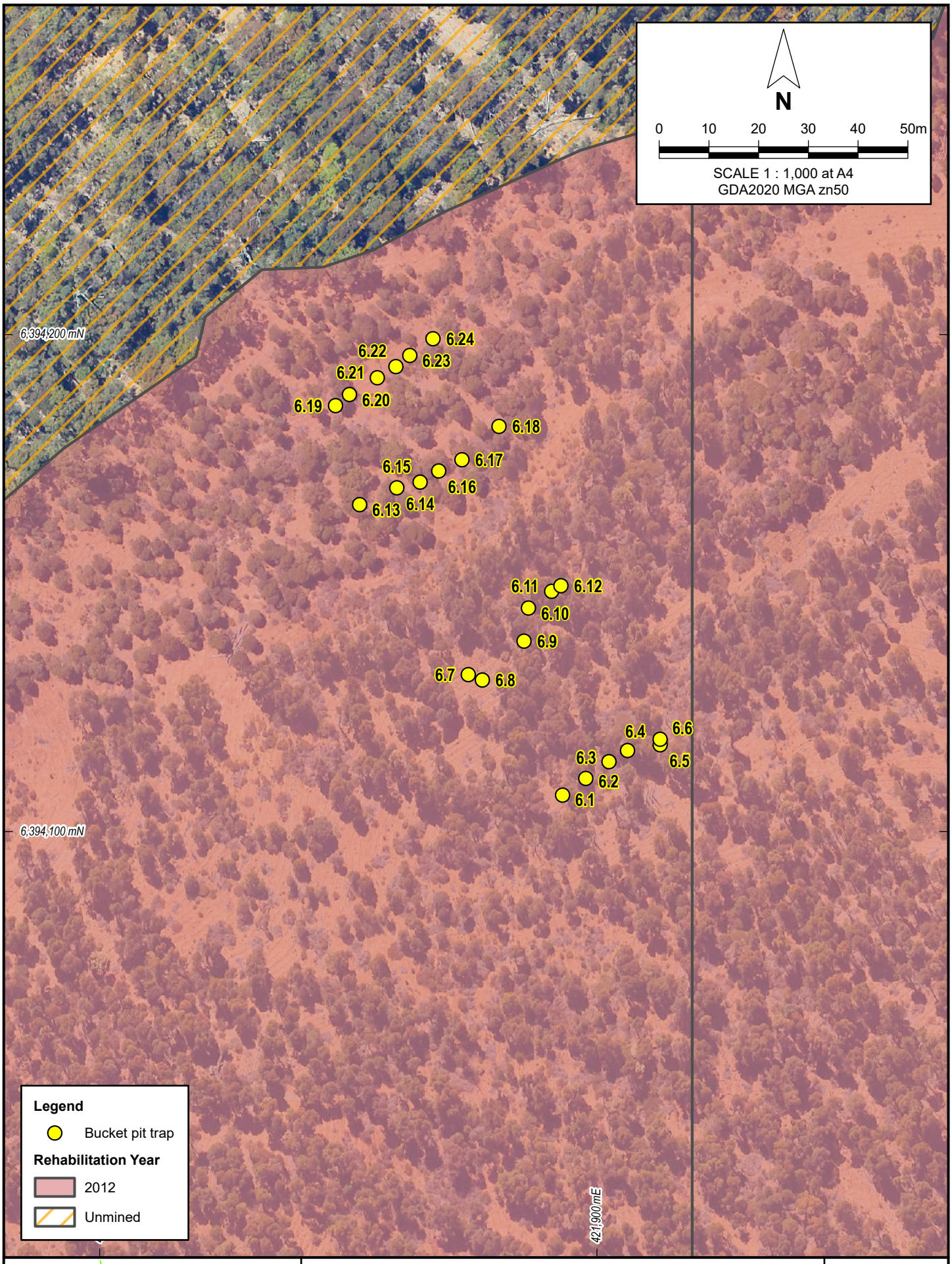
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IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

PIT TRAP LOCATIONS - TRAP SITE 5

Figure 7

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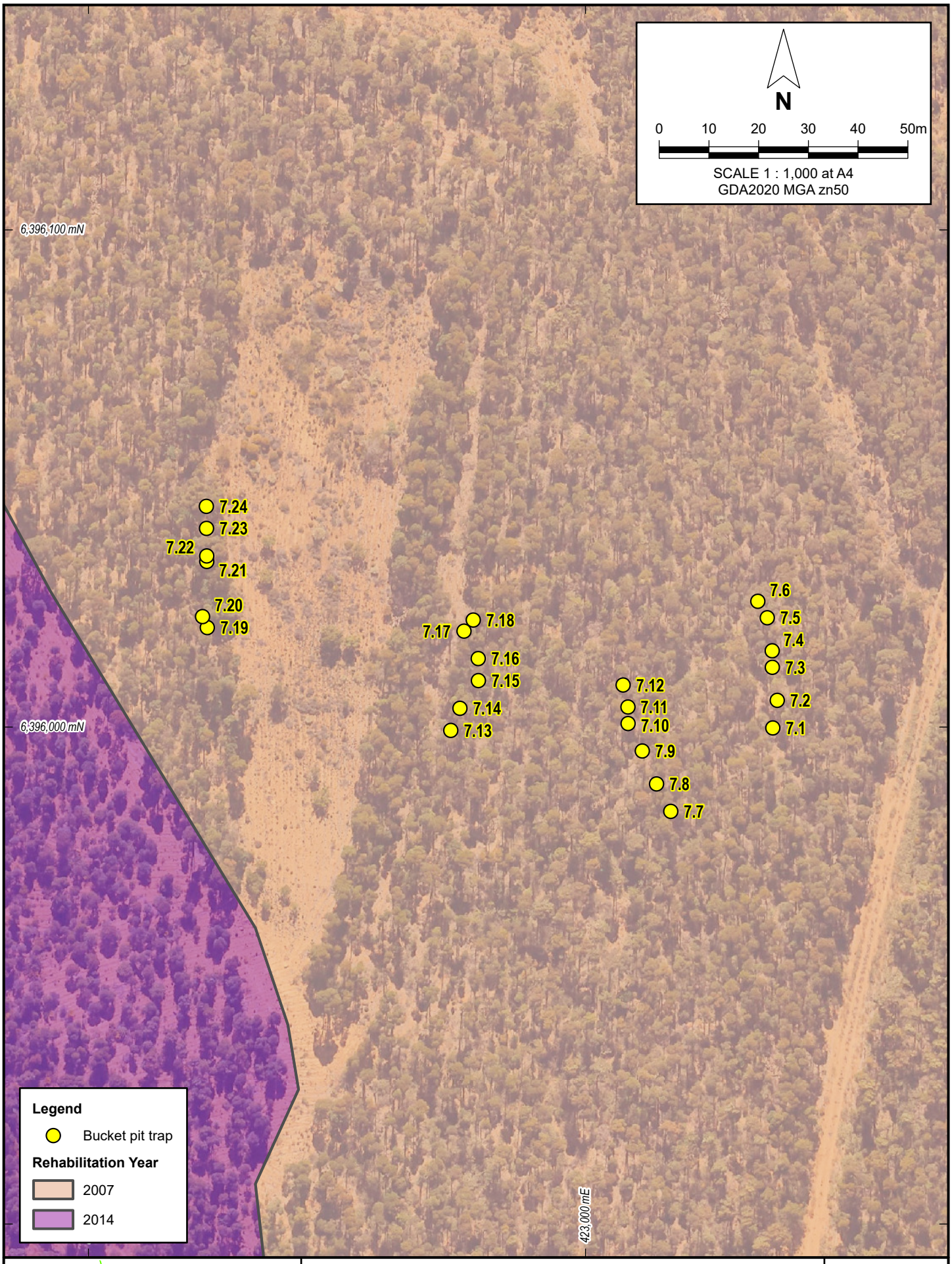
TERRESTRIAL ECOSYSTEMS

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Figure 8

PIT TRAP LOCATIONS - TRAP SITE 6

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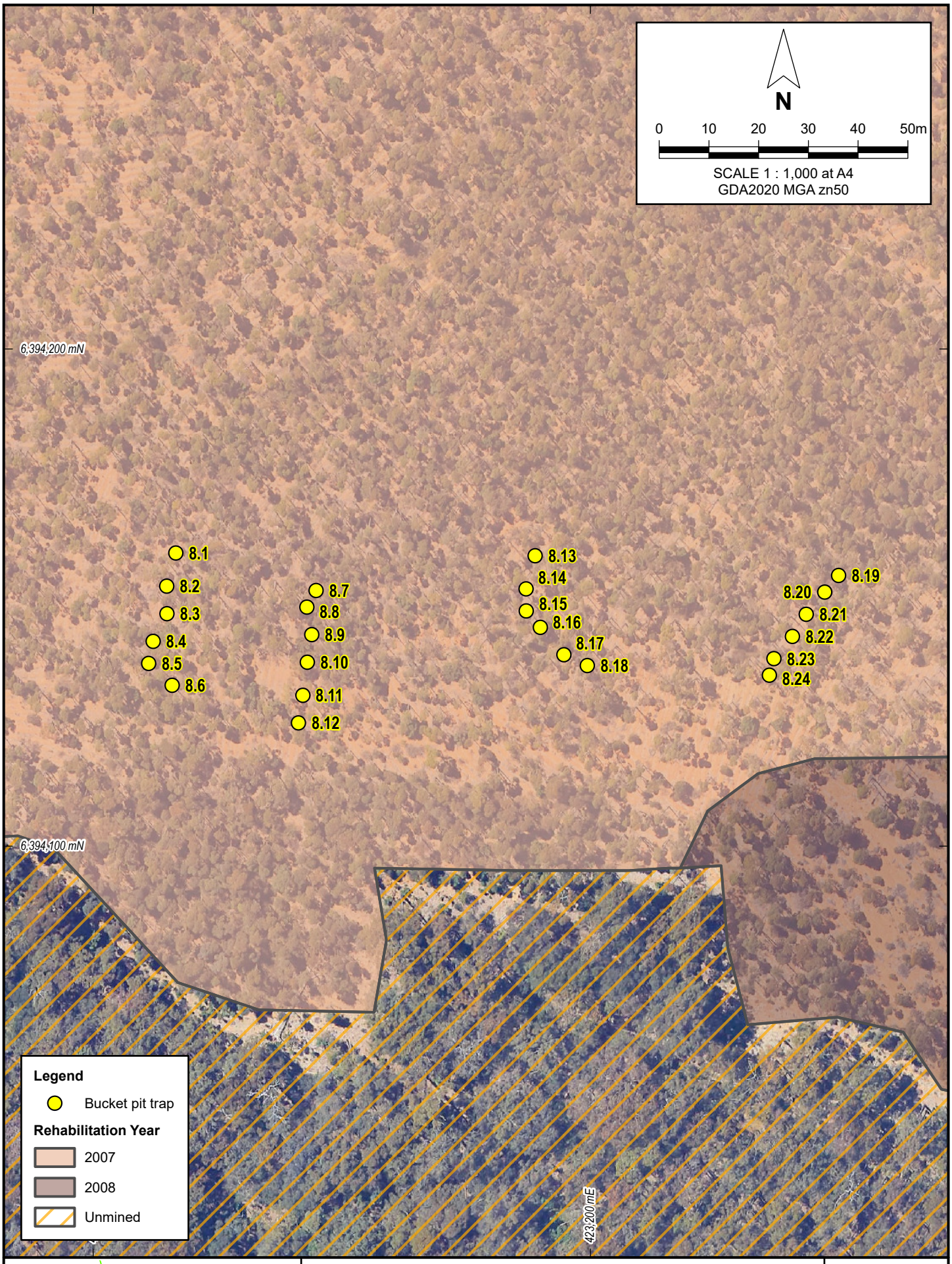
TERRESTRIAL ECOSYSTEMS

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IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

PIT TRAP LOCATIONS - TRAP SITE 7

Figure 9

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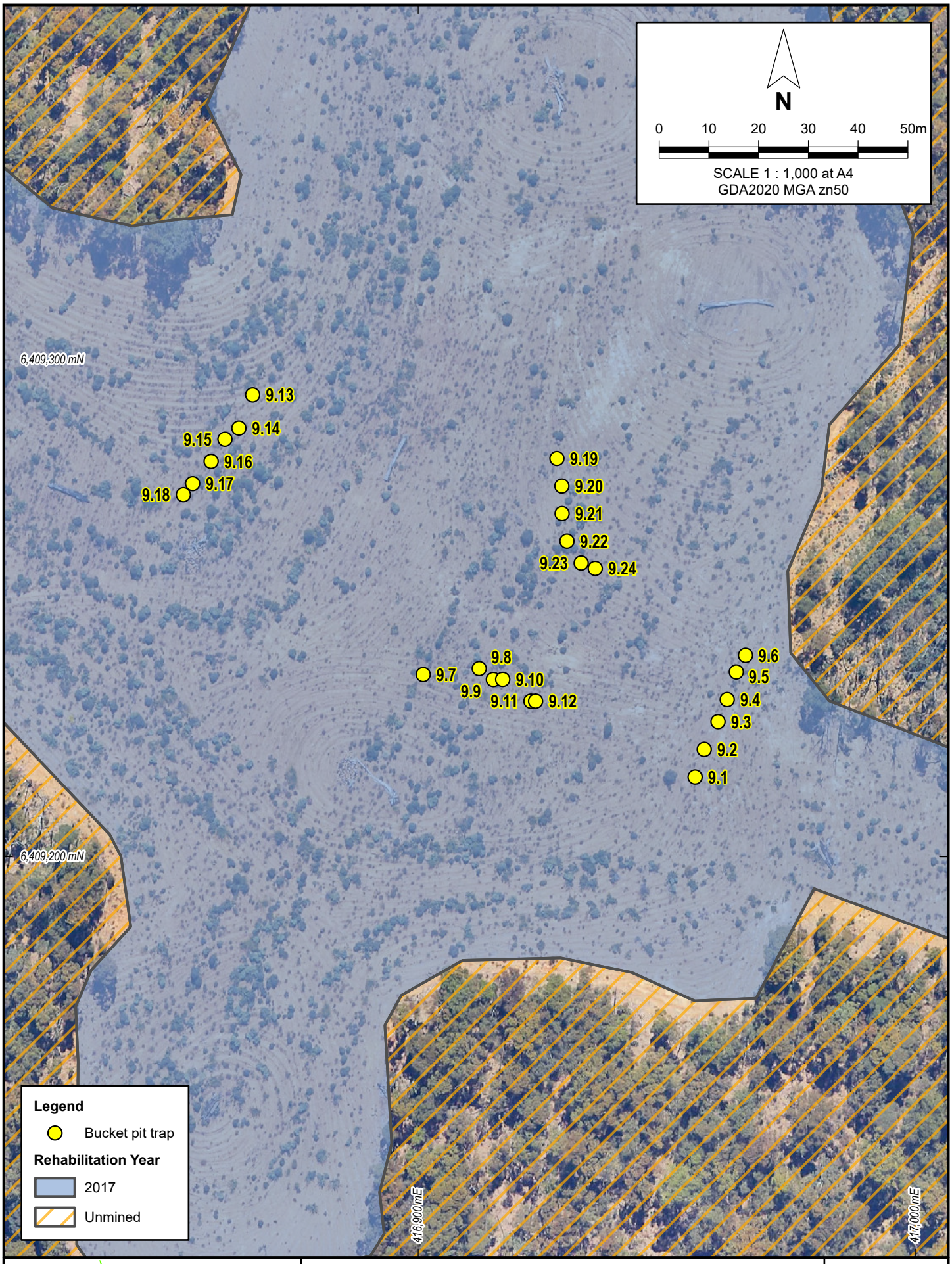
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IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

PIT TRAP LOCATIONS - TRAP SITE 8

Figure 10

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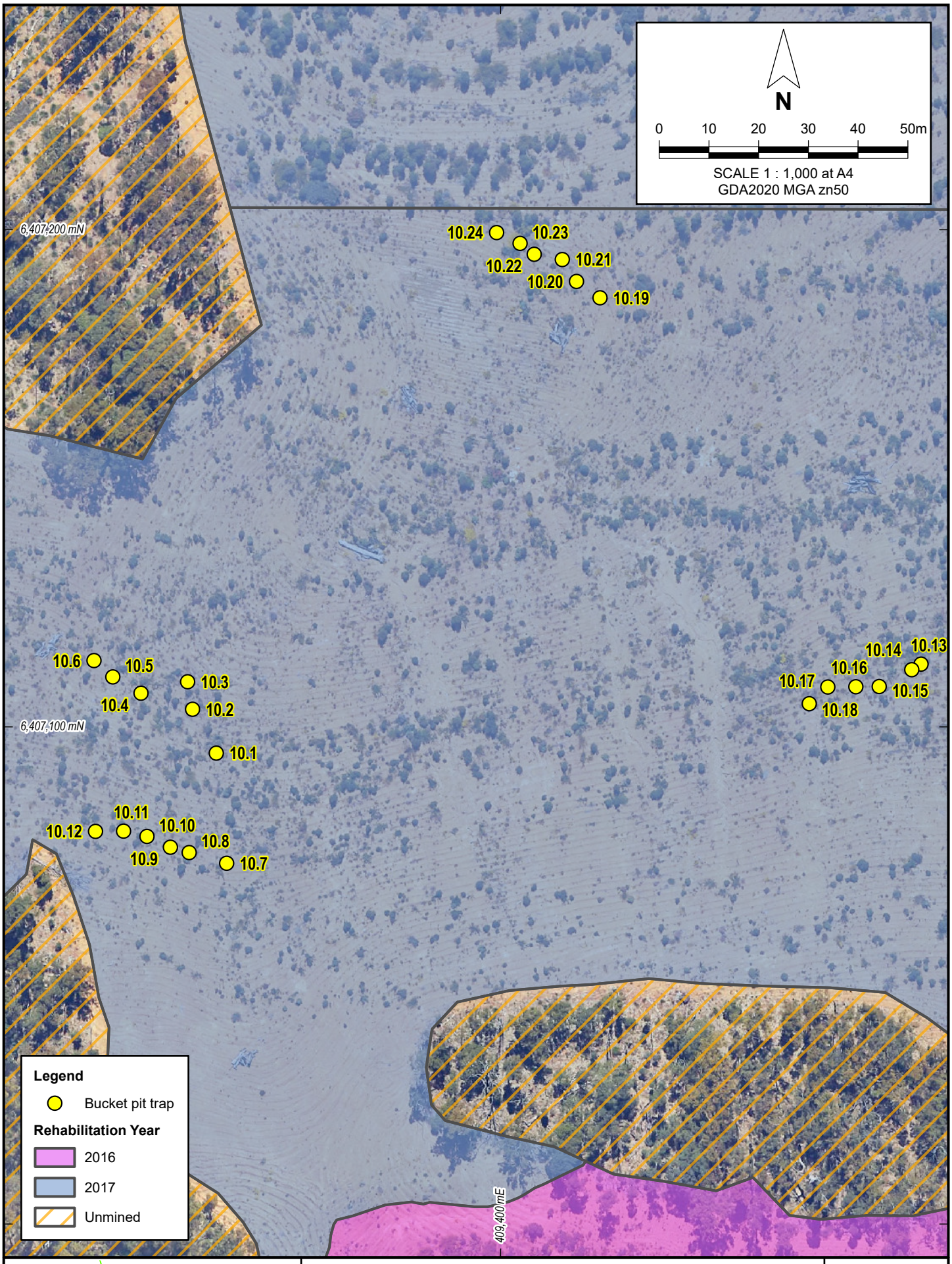
TERRESTRIAL ECOSYSTEMS

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BASELINE MONITORING SURVEY OF REHABILITATION PROGRAMS
IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

Figure 11

PIT TRAP LOCATIONS - TRAP SITE 9

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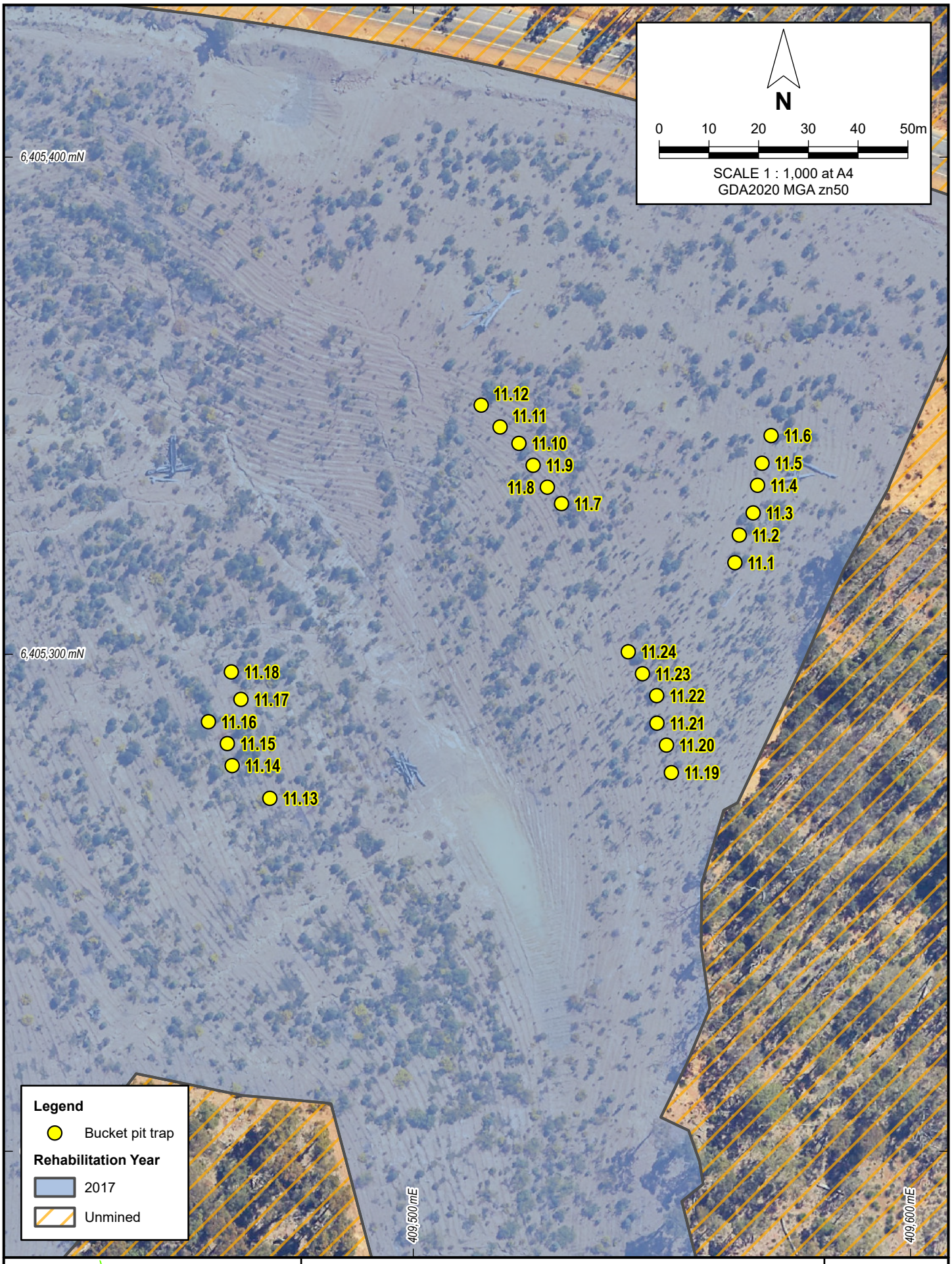
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IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

PIT TRAP LOCATIONS - TRAP SITE 10

Figure 12

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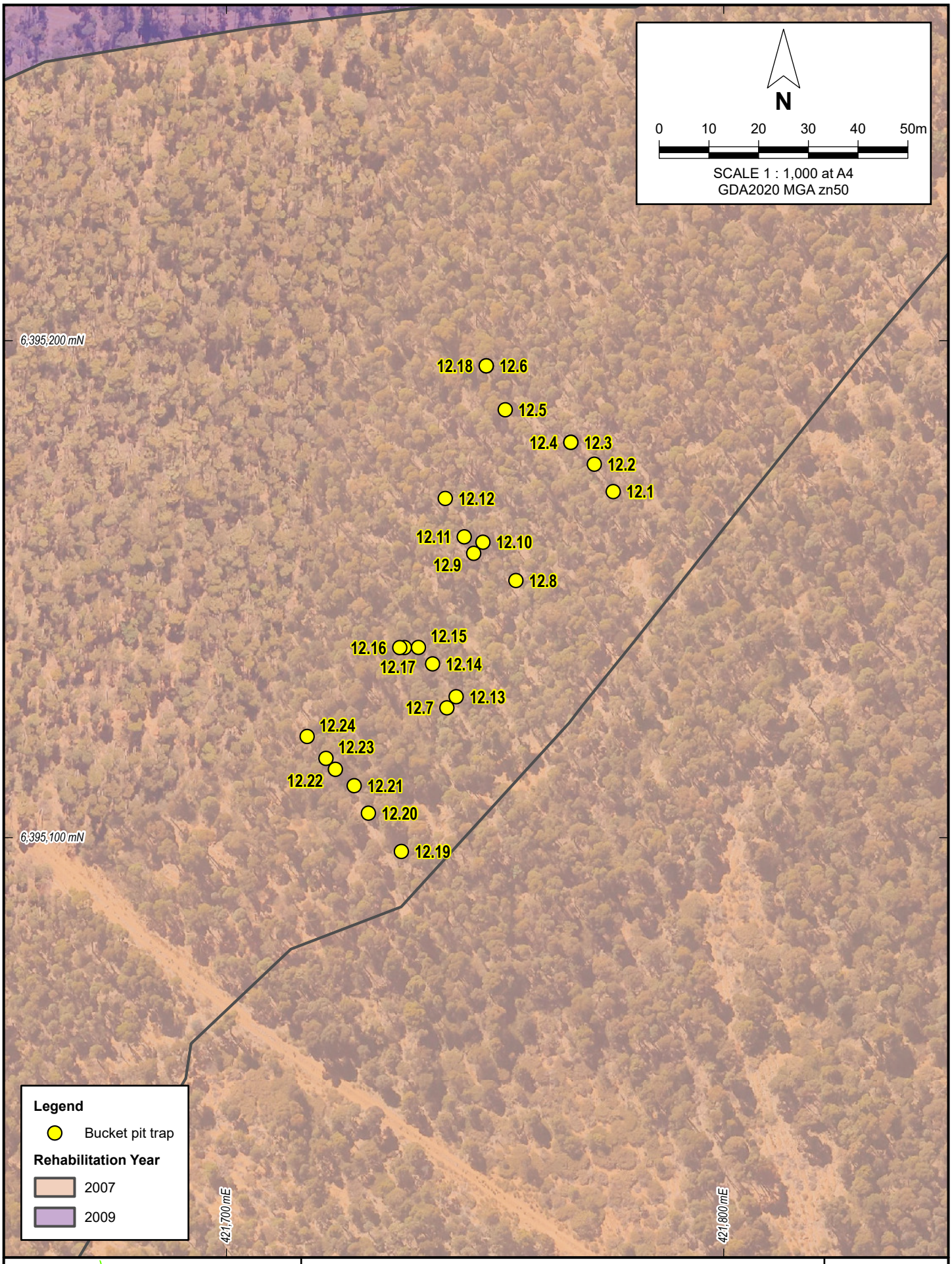
TERRESTRIAL ECOSYSTEMS

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IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

Figure 13

PIT TRAP LOCATIONS - TRAP SITE 11

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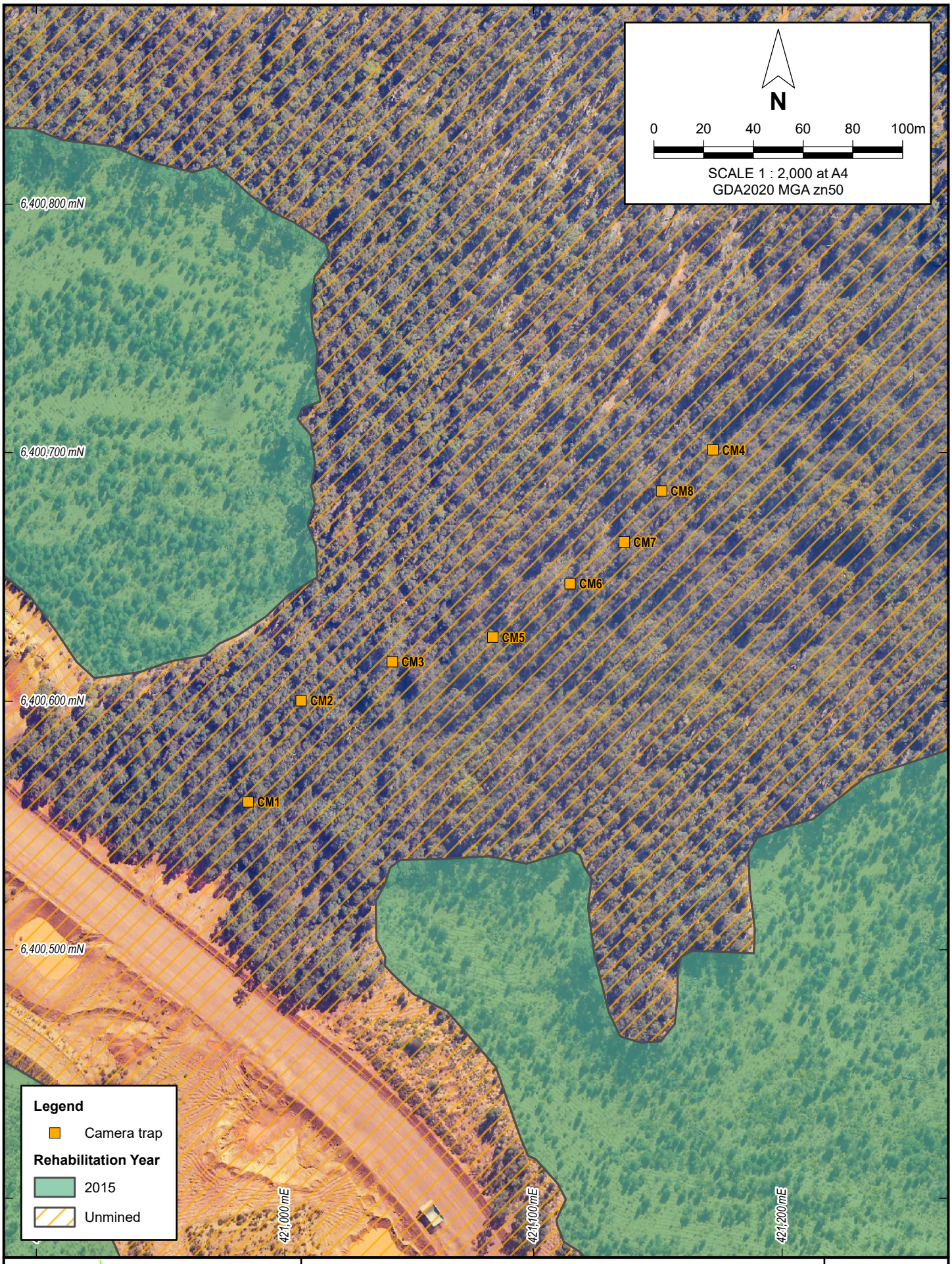
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IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

Figure 14

PIT TRAP LOCATIONS - TRAP SITE 12

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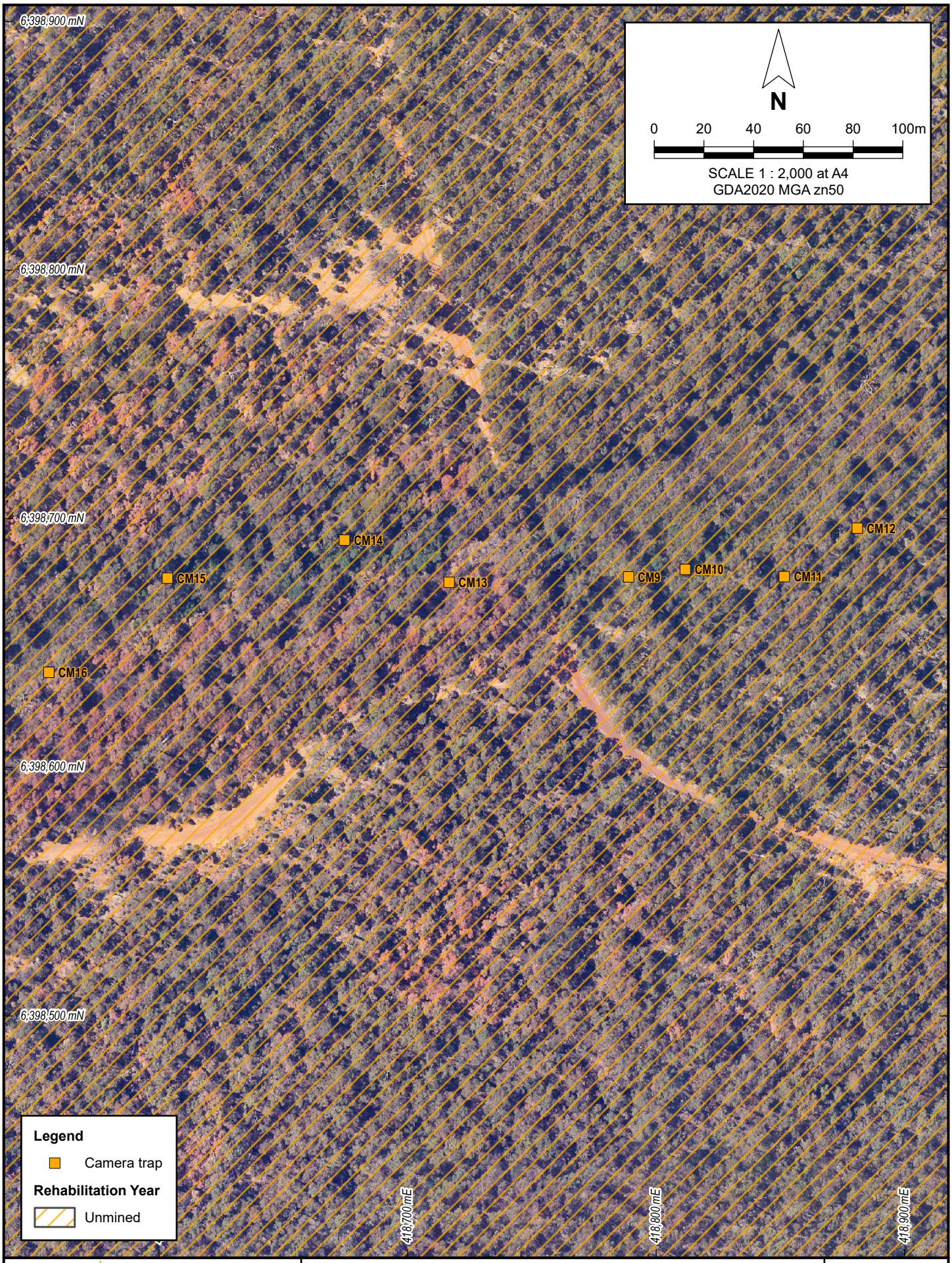
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CAMERA TRAP LOCATION - SITE 1

Figure 15

Job: 2023-0056



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IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

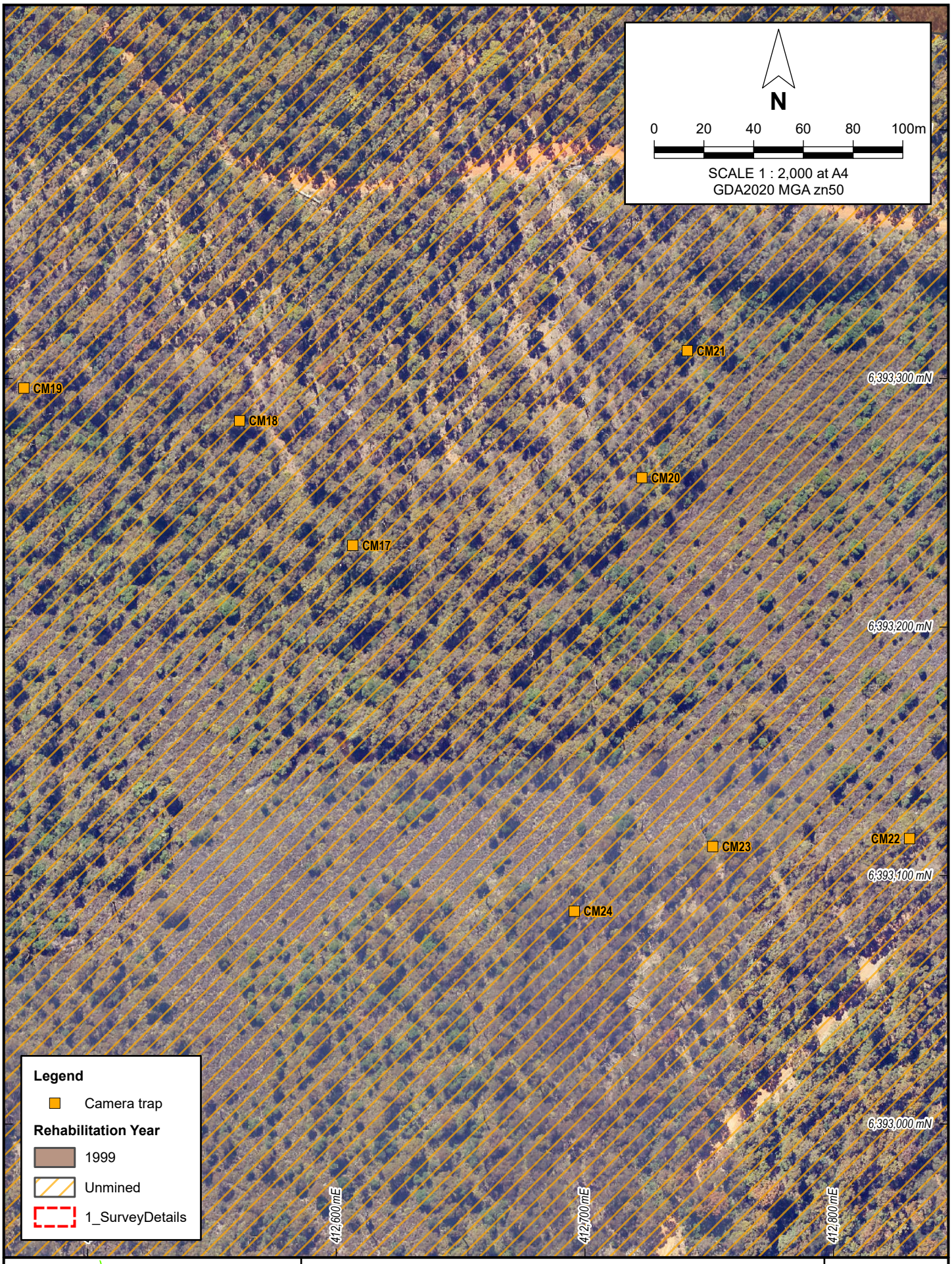
Figure 16

CAMERA TRAP LOCATION - SITE 2

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Job: 2023-0056



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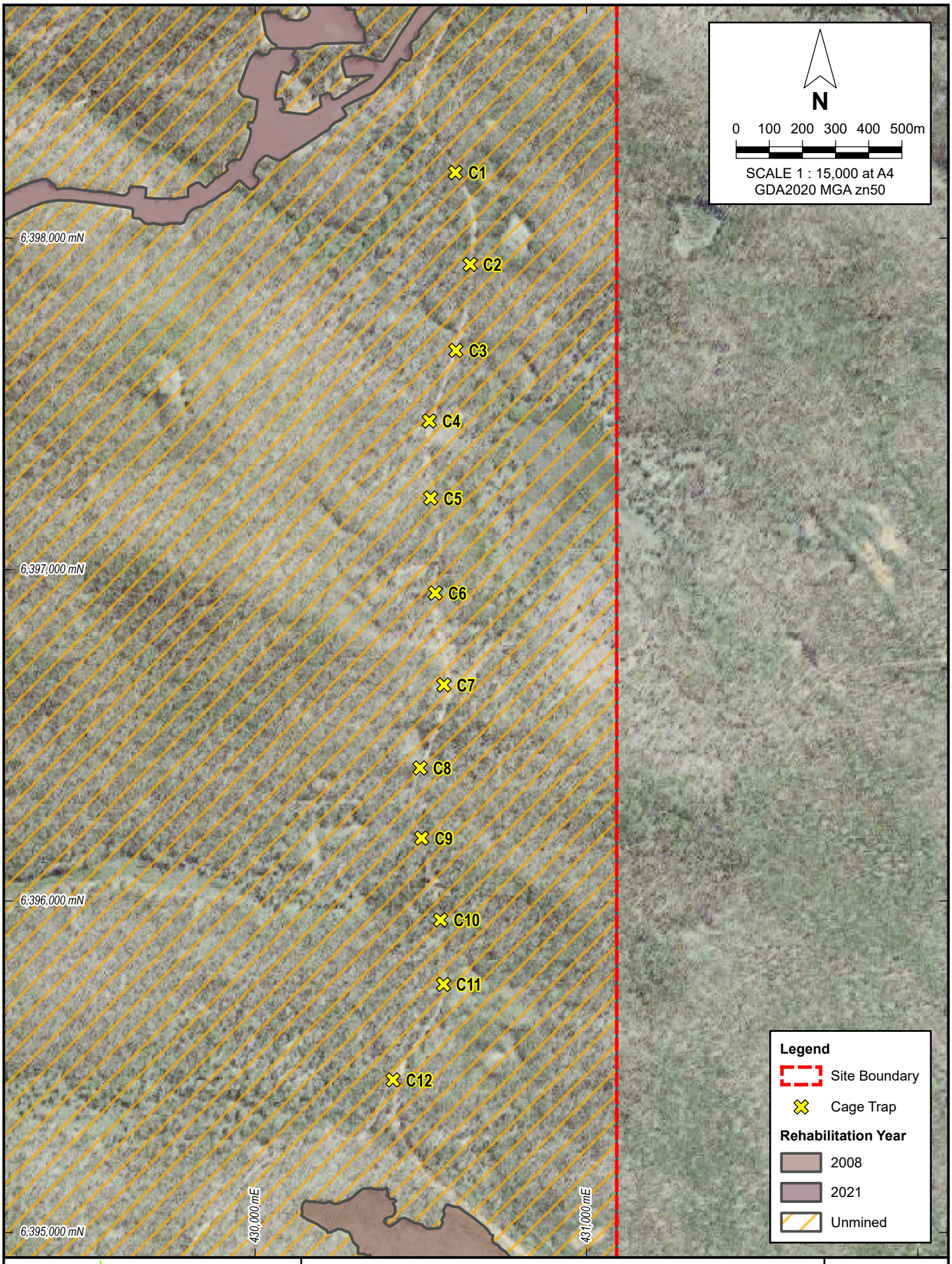
TERRESTRIAL ECOSYSTEMS

Alcoa of Australia Ltd
BASELINE MONITORING SURVEY OF REHABILITATION PROGRAMS IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

Figure 17

CAMERA TRAP LOCATION - SITE 3

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TERRESTRIAL ECOSYSTEMS

Drawn: G. Thompson | Date: 23 Aug 2023

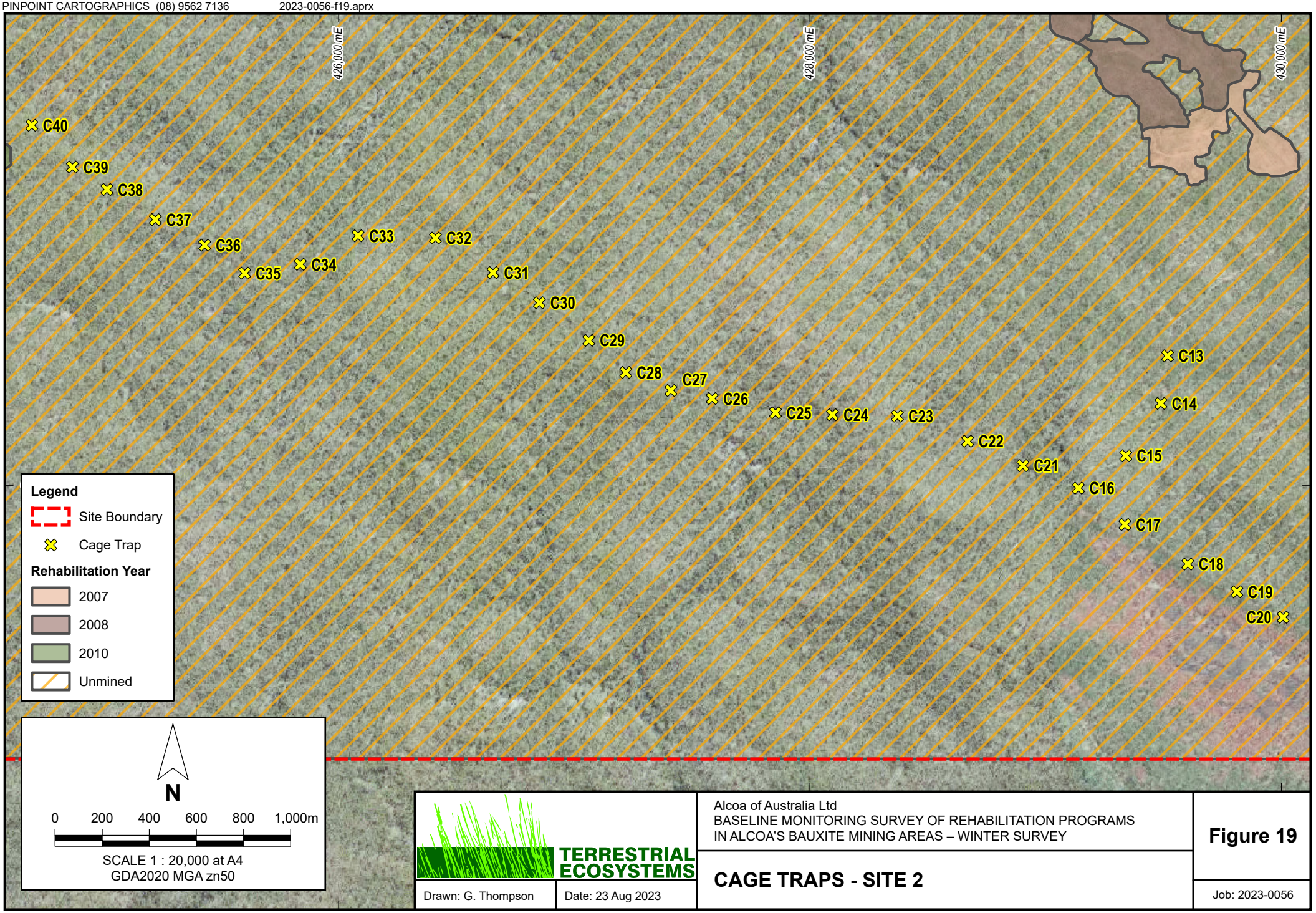
Alcoa of Australia Ltd
BASELINE MONITORING SURVEY OF REHABILITATION PROGRAMS IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

CAGE TRAPS - SITE 1

Figure 18

Job: 2023-0056

PINPOINT CARTOGRAPHICS (08) 9562 7136 2023-0056-f19.aprx



TERRESTRIAL ECOSYSTEMS

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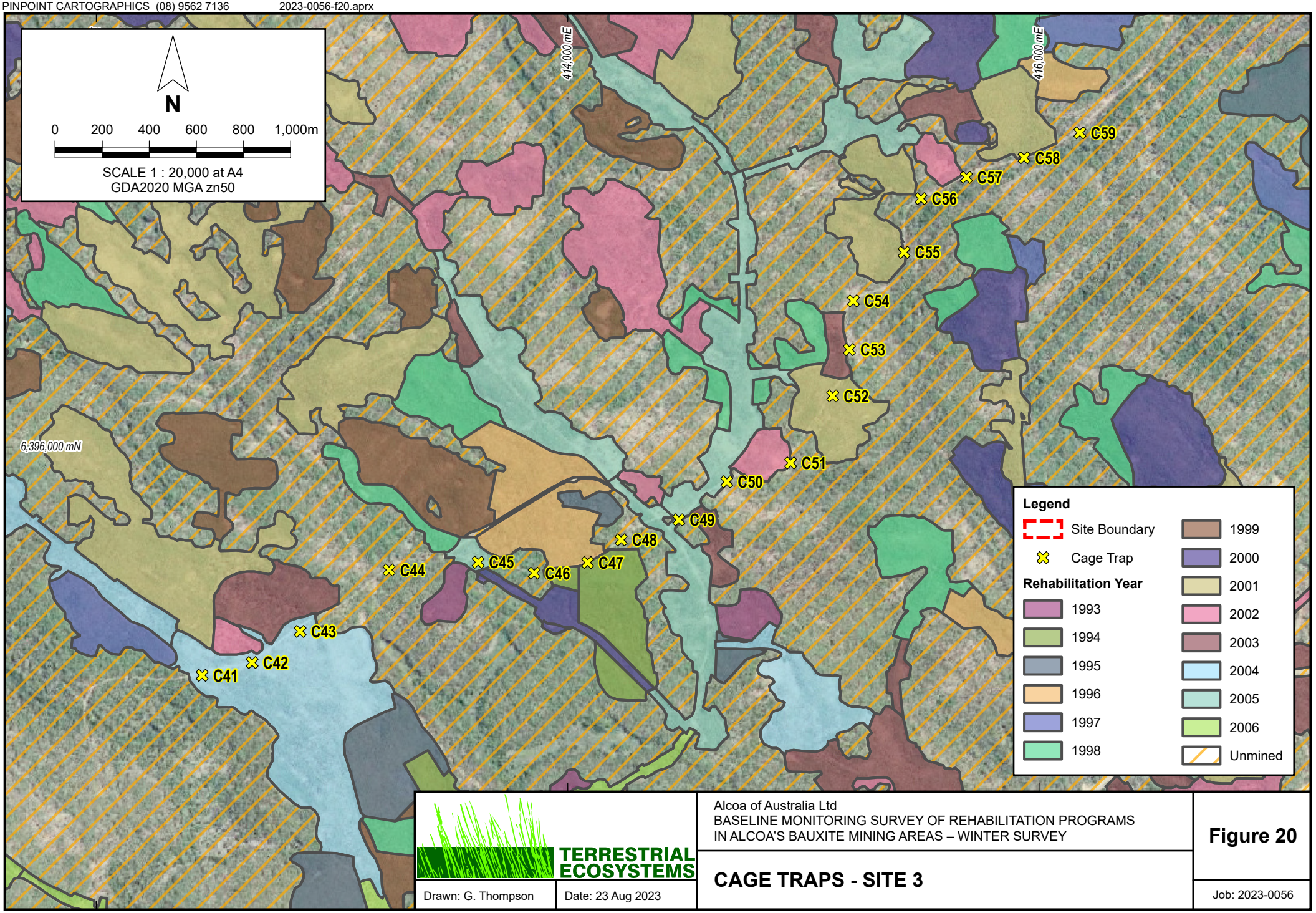
Date: 23 Aug 2023

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CAGE TRAPS - SITE 2

Figure 19

Job: 2023-0056



TERRESTRIAL ECOSYSTEMS

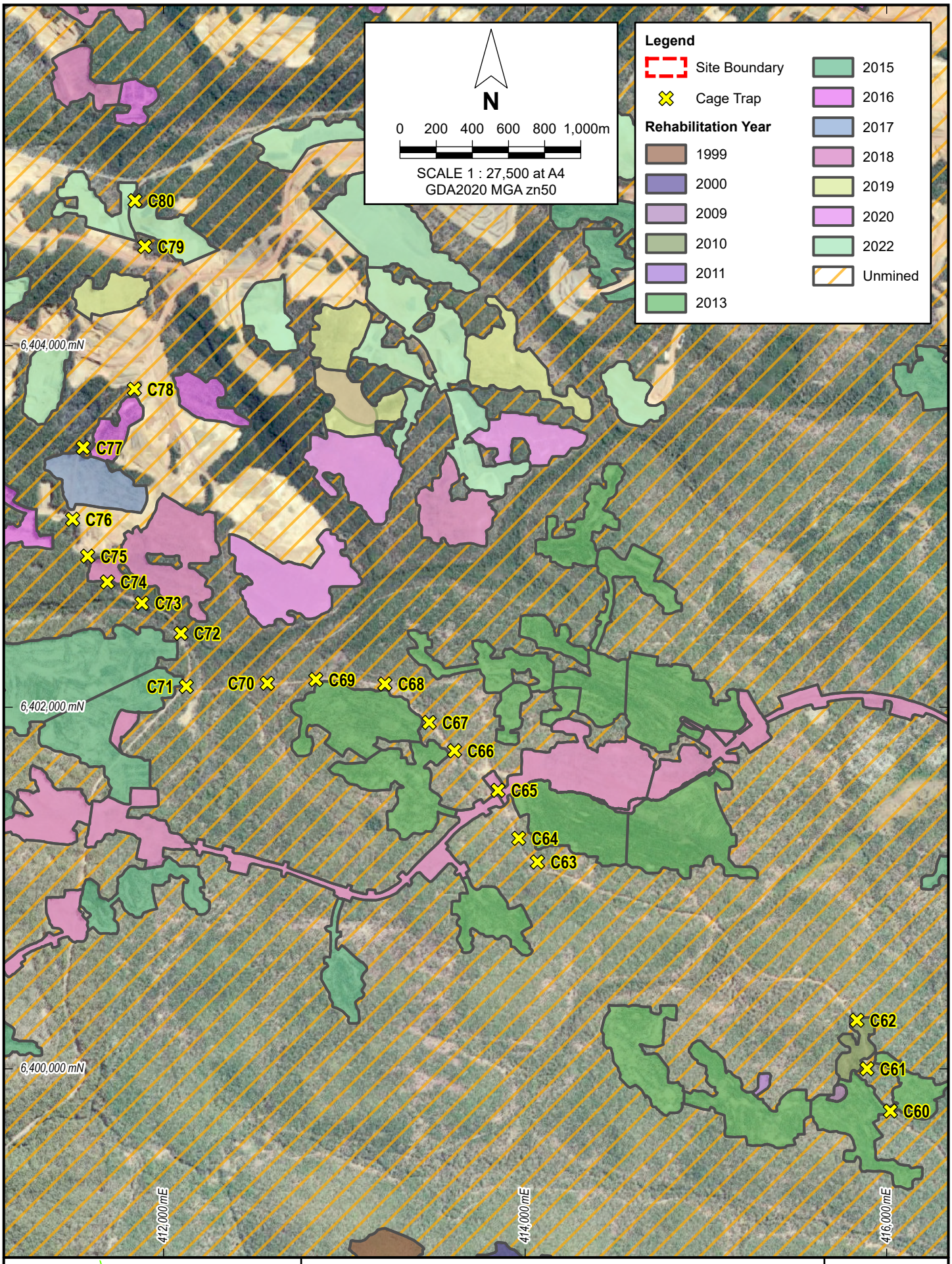
Drawn: G. Thompson | Date: 23 Aug 2023

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BASELINE MONITORING SURVEY OF REHABILITATION PROGRAMS IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

CAGE TRAPS - SITE 3

Figure 20

Job: 2023-0056



PINPOINT CARTOGRAPHICS (08) 9562 7136

2023-0056.mxd

TERRESTRIAL ECOSYSTEMS

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Date: 23 Aug 2023

Alcoa of Australia Ltd
BASELINE MONITORING SURVEY OF REHABILITATION PROGRAMS
IN ALCOA'S BAUXITE MINING AREAS – WINTER SURVEY

CAGE TRAPS - SITE 4

Figure 21

Job: 2023-0056

Appendix A.
Site habitat images

Baseline Monitoring of Rehabilitation Programs in Alcoa's Bauxite Mining Areas
Winter Survey





Plate 21. Site 1 Unmined



Plate 22. Site 1 Unmined



Plate 23. Site 2 unmined



Plate 24. Site 2 unmined



Plate 25. Site 3 unmined



Plate 26. Site 3 unmined



Plate 27. Site 7 15-year rehabilitation



Plate 28. Site 7 15-year rehabilitation



Plate 29. Site 8 15-year rehabilitation



Plate 30. Site 8 15-year rehabilitation



Plate 31. Site 12 15-year rehabilitation



Plate 32. Site 12 15-year rehabilitation



Plate 33. Site 4 10-year rehabilitation



Plate 34. Site 4 10-year rehabilitation



Plate 35. Site 5 10-year rehabilitation



Plate 36. Site 5 10-year rehabilitation



Plate 37. Site 6 10-year rehabilitation



Plate 38. Site 6 10-year rehabilitation



Plate 39. Site 9 5-year rehabilitation



Plate 40. Site 9 5-year rehabilitation



Plate 41. Site 10 5-year rehabilitation



Plate 42. Site 10 5-year rehabilitation



Plate 43. Site 11 5-year rehabilitation



Plate 44. Site 11 5-year rehabilitation

Appendix B.
Trapping site coordinates

Baseline Monitoring of Rehabilitation Programs in Alcoa's Bauxite Mining Areas
Winter Survey



B.1 TRAP LOCATIONS (GDA 94, ZONE 50)

Trap #	Easting	Northing	Date opened	Date closed
Pit and funnel traps				
1.A	428680	6397362	27/6/2023	9/7/2023
1.B	428703	6397351	27/6/2023	9/7/2023
1.C	428729	6397339	27/6/2023	9/7/2023
1.D	428763	6397366	27/6/2023	9/7/2023
2.A	421553	6401260	27/6/2023	9/7/2023
2.B	421576	6401290	27/6/2023	9/7/2023
2.C	421531	6401223	27/6/2023	9/7/2023
2.D	421544	6401247	27/6/2023	9/7/2023
3.A	417176	6398886	27/6/2023	9/7/2023
3.B	417156	6398820	27/6/2023	9/7/2023
3.C	417115	6398794	27/6/2023	9/7/2023
3.D	417104	6398755	27/6/2023	9/7/2023
4.A	418660	6399587	27/6/2023	9/7/2023
4.B	418668	6399563	27/6/2023	9/7/2023
4.C	418676	6399540	27/6/2023	9/7/2023
4.D	418679	6399517	27/6/2023	9/7/2023
5.A	420382	6401508	27/6/2023	9/7/2023
5.B	420410	6401518	27/6/2023	9/7/2023
5.C	420455	6401509	27/6/2023	9/7/2023
5.D	420479	6401534	27/6/2023	9/7/2023
6.A	421911	6394117	27/6/2023	9/7/2023
6.B	421891	6394147	27/6/2023	9/7/2023
6.C	421879	6394180	27/6/2023	9/7/2023
6.D	421866	6394197	27/6/2023	9/7/2023
7.A	422922	6396018	27/6/2023	9/7/2023
7.B	422976	6396020	27/6/2023	9/7/2023
7.C	423016	6395981	27/6/2023	9/7/2023
7.D	423033	6396023	27/6/2023	9/7/2023
8.A	423113	6394130	27/6/2023	9/7/2023
8.B	423140	6394123	27/6/2023	9/7/2023

Trap #	Easting	Northing	Date opened	Date closed
8.C	423198	6394134	27/6/2023	9/7/2023
8.D	423235	6394132	27/6/2023	9/7/2023
9.A	416954	6409214	27/6/2023	9/7/2023
9.B	416922	6409229	27/6/2023	9/7/2023
9.C	416934	6409256	27/6/2023	9/7/2023
9.D	416851	6409271	27/6/2023	9/7/2023
10.A	409342	6407093	27/6/2023	9/7/2023
10.B	409343	6407071	27/6/2023	9/7/2023
10.C	409483	6407111	27/6/2023	9/7/2023
10.D	409398	6407197	27/6/2023	9/7/2023
11.A	409470	6405269	27/6/2023	9/7/2023
11.B	409550	6405274	27/6/2023	9/7/2023
11.C	409528	6405328	27/6/2023	9/7/2023
11.D	409563	6405316	27/6/2023	9/7/2023
12.A	421738	6395132	27/6/2023	9/7/2023
12.B	421743	6395166	27/6/2023	9/7/2023
12.C	421751	6395192	27/6/2023	9/7/2023
12.D	421715	6395118	27/6/2023	9/7/2023
Camera traps				
CM1	420969	6400570	26/06/2023	9/07/2023
CM2	421001	6400591	26/06/2023	9/07/2023
CM3	421069	6400626	26/06/2023	9/07/2023
CM4	421158	6400680	26/06/2023	9/07/2023
CM5	421193	6400728	26/06/2023	9/07/2023
CM6	421213	6400731	26/06/2023	9/07/2023
CM7	421168	6400702	26/06/2023	9/07/2023
CM8	421136	6400657	26/06/2023	9/07/2023
CM9	418789	6398679	26/06/2023	9/07/2023
CM10	418901	6398694	26/06/2023	9/07/2023
CM11	418989	6398723	26/06/2023	9/07/2023
CM12	418750	6398714	26/06/2023	9/07/2023
CM13	418828	6398753	26/06/2023	9/07/2023
CM14	418857	6398770	26/06/2023	9/07/2023

Trap #	Easting	Northing	Date opened	Date closed
CM15	418685	6398687	26/06/2023	9/07/2023
CM16	418592	6398667	26/06/2023	9/07/2023
CM17	412297	6393542	26/06/2023	9/07/2023
CM18	412360	6393411	26/06/2023	9/07/2023
CM19	412550	6393205	26/06/2023	9/07/2023
CM20	412633	6393199	26/06/2023	9/07/2023
CM21	412695	6393235	26/06/2023	9/07/2023
CM22	412840	6393138	26/06/2023	9/07/2023
CM23	412790	6393121	26/06/2023	9/07/2023
CM24	412669	6393084	26/06/2023	9/07/2023
Cage traps				
C1	430604	6398198	26/06/2023	9/07/2023
C2	430648	6397921	26/06/2023	9/07/2023
C3	430605	6397661	26/06/2023	9/07/2023
C4	430525	6397448	26/06/2023	9/07/2023
C5	430529	6397215	26/06/2023	9/07/2023
C6	430543	6396929	26/06/2023	9/07/2023
C7	430569	6396652	26/06/2023	9/07/2023
C8	430497	6396401	26/06/2023	9/07/2023
C9	430502	6396189	26/06/2023	9/07/2023
C10	430559	6395942	26/06/2023	9/07/2023
C11	430568	6395748	26/06/2023	9/07/2023
C12	430416	6395460	26/06/2023	9/07/2023
C13	429517	6390549	26/06/2023	9/07/2023
C14	429488	6390347	26/06/2023	9/07/2023
C15	429339	6390125	26/06/2023	9/07/2023
C16	429138	6389988	26/06/2023	9/07/2023
C17	429336	6389833	26/06/2023	9/07/2023
C18	429602	6389666	26/06/2023	9/07/2023
C19	429811	6389548	26/06/2023	9/07/2023
C20	430007	6389440	26/06/2023	9/07/2023
C21	428903	6390083	26/06/2023	9/07/2023
C22	428668	6390187	26/06/2023	9/07/2023

Trap #	Easting	Northing	Date opened	Date closed
C23	428371	6390293	26/06/2023	9/07/2023
C24	428095	6390299	26/06/2023	9/07/2023
C25	427853	6390307	26/06/2023	9/07/2023
C26	427585	6390368	26/06/2023	9/07/2023
C27	427410	6390402	26/06/2023	9/07/2023
C28	427218	6390478	26/06/2023	9/07/2023
C29	427061	6390614	26/06/2023	9/07/2023
C30	426852	6390774	26/06/2023	9/07/2023
C31	426655	6390902	26/06/2023	9/07/2023
C32	426410	6391048	26/06/2023	9/07/2023
C33	426082	6391058	26/06/2023	9/07/2023
C34	425837	6390937	26/06/2023	9/07/2023
C35	425601	6390900	26/06/2023	9/07/2023
C36	425432	6391018	26/06/2023	9/07/2023
C37	425222	6391127	26/06/2023	9/07/2023
C38	425017	6391254	26/06/2023	9/07/2023
C39	424871	6391350	26/06/2023	9/07/2023
C40	424699	6391527	26/06/2023	9/07/2023
C41	412449	6395031	26/06/2023	9/07/2023
C42	412661	6395085	26/06/2023	9/07/2023
C43	412864	6395217	26/06/2023	9/07/2023
C44	413242	6395477	26/06/2023	9/07/2023
C45	413619	6395510	26/06/2023	9/07/2023
C46	413857	6395464	26/06/2023	9/07/2023
C47	414084	6395509	26/06/2023	9/07/2023
C48	414226	6395605	26/06/2023	9/07/2023
C49	414471	6395690	26/06/2023	9/07/2023
C50	414674	6395851	26/06/2023	9/07/2023
C51	414945	6395931	26/06/2023	9/07/2023
C52	415124	6396216	26/06/2023	9/07/2023
C53	415194	6396412	26/06/2023	9/07/2023
C54	415211	6396619	26/06/2023	9/07/2023
C55	415426	6396824	26/06/2023	9/07/2023

Trap #	Easting	Northing	Date opened	Date closed
C56	415498	6397052	26/06/2023	9/07/2023
C57	415691	6397143	26/06/2023	9/07/2023
C58	415935	6397226	26/06/2023	9/07/2023
C59	416172	6397331	26/06/2023	9/07/2023
C60	416020	6399766	26/06/2023	9/07/2023
C61	415891	6399999	26/06/2023	9/07/2023
C62	415835	6400268	26/06/2023	9/07/2023
C63	414068	6401144	26/06/2023	9/07/2023
C64	413964	6401275	26/06/2023	9/07/2023
C65	413850	6401540	26/06/2023	9/07/2023
C66	413609	6401759	26/06/2023	9/07/2023
C67	413469	6401915	26/06/2023	9/07/2023
C68	413224	6402128	26/06/2023	9/07/2023
C69	412842	6402153	26/06/2023	9/07/2023
C70	412574	6402132	26/06/2023	9/07/2023
C71	412126	6402114	26/06/2023	9/07/2023
C72	412096	6402408	26/06/2023	9/07/2023
C73	411880	6402575	26/06/2023	9/07/2023
C74	411689	6402693	26/06/2023	9/07/2023
C75	411580	6402835	26/06/2023	9/07/2023
C76	411496	6403039	26/06/2023	9/07/2023
C77	411555	6403436	26/06/2023	9/07/2023
C78	411838	6403759	26/06/2023	9/07/2023
C79	411896	6404549	26/06/2023	9/07/2023
C80	411841	6404802	26/06/2023	9/07/2023


DETECTION DOG