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Report on a survey to  
determine the  
distribution of Whicher  
Floristic Community  
Type C2

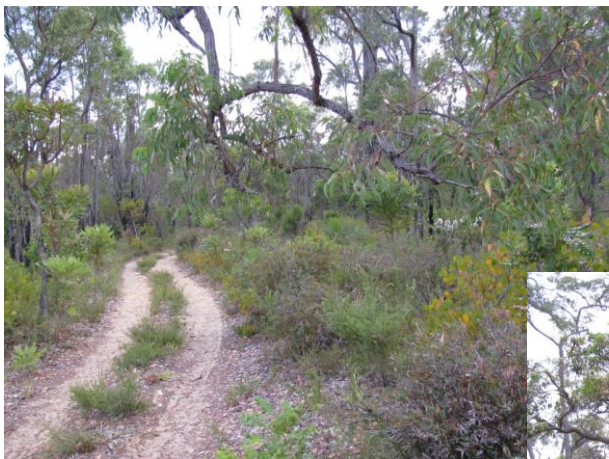
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Prepared for *Strategen* on  
behalf of Bemax Resources

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# SUMMARY

The newly listed Priority Ecological Community “Whicher Scarp Jarrah woodland of deep coloured sands” (FCT C2) occurs within the Happy Valley North and Happy Valley South mining leases held by Bemax Resources. The Department of Environment and Conservation has requested additional information on the impact of mining proposals on the regional distribution of the C2 community.

A survey was carried out of known and prospective sites along the Whicher Scarp to get a better understanding of the distribution and extent of FCT C2. A method is described by which the boundaries of FCT C2 are determined in the field using a rapid survey method.

Twenty two sites with a total of 294 ha of the community were located and mapped.

## 1. INTRODUCTION

### *1.1. Regional Setting and Soils*

The Whicher Scarp, a sickle-shaped band of low hills up to 180 mAHD, but typically from 100-140 mAHD, forms the southern margin of the Swan Coastal Plain between Burekup and Dunsborough. It is thought to have formed as a result of marine erosion of the Perth Sedimentary Basin (Playford *et al.*, 1976). The Ridge Hill Shelf forms foothills along the base of the Darling and Whicher Scarps (McArthur and Bettenay, 1960) occupying the 30-50 mAHD elevation range. Baxter (1977), in a more detailed geological description, divides the footslopes of the Darling and Whicher Scarps into three components:

- the Ridge Hill Dune System, “situated on the upper edge of the Ridge Hill Shelf, is a podsolised beach ridge and dune system incised into and overlapping the Whicher and Darling Scarps, with a base of approximately 76 mAHD”<sup>1</sup>
- the Yoganup Dune System, being “podsolised dunes and beach ridges at the foot of the Ridge Hill Shelf, lying between 25 and 50 mAHD”.

The Happy Valley deposits are part of the Ridge Hill Dune System, with a basement at approximately 80 mAHD (Strategen, 2009).

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<sup>1</sup> The base of the Ridge Hill Dune System must be lower than 76 m along the Whicher Scarp because the Ridge Hill Shelf, which along the base of the Darling Scarp is lies between the Ridge Hill Dune Shelf and the Yoganup Dune System is reported to be absent from the Whicher Scarp (Seddon, 1972).

The soils of the Whicher Scarp are principally duplex sandy gravels, yellow deep sands and sandy earths, loamy gravels and wet and semi-wet soils. Less commonly grey deep sandy duplex soils, pale deep sands, shallow gravels and brown deep sands occur.

## **1.2. The flora and vegetation of the Whicher Scarp**

Following the publication of a report on a survey of flora and vegetation of the Whicher Scarp (Keighery *et al.*, 2008) one of the floristic community types (FCTs) identified by the survey has been listed as a Priority Ecological Community. This FCT, with the code “C2” and named the “Whicher Scarp Jarrah woodland of deep coloured sands” (hereafter referred to as FCT C2) is part of Vegetation Community Group C: “Whicher Scarp woodlands of deep coloured sands and laterites”. The listing of FCT C2 has implications for Bemax Resources which is in the process of getting approval to establish a mineral sands mine on their “Happy Valley North” and “Happy Valley South” mining leases.

The ‘Happy Valley North’ deposit (HVN) is situated south of Gavin’s Road in the Argyle State Forest Block and also extends north of Gavin’s Rd on private property (Loc 215). The ‘Happy Valley South’ deposit occurs approximately 1.5 km south west of HVN; half of the deposit overlays a corner of the Argyle State Forest Block, with the remainder occurring on privately owned land. The area of native vegetation proposed to be cleared at the HVN and HVS project areas would be 78 ha and 64 ha respectively, with 55 ha (across both leases) in State forest (Strategen, 2009).

Both the HVN and HVS leases (hereafter called the “Happy Valley lease area) have been shown to contain areas of FCT C2 based on multivariate analysis of quadrat floristic data derived from the Whicher Study and quadrats placed within the mining area by consultants who have mapped the vegetation for Bemax Resources (Bennett Environmental Consulting and Onshore Environmental Consultants Pty Ltd, 2006; Bennett Environmental Consulting, 2007). The Happy Valley lease area vegetation mapping units which have FCT C2 quadrats within them are;

- *EmChXoBgRcDnSIHhSwDI* (6 quadrats)
- *EmAfChMtHh* (2 quadrats)
- *EmCcChBgDhHhSI* (1 quadrat)
- *EmCcChBgXoPIxpXaDhHhCsDI* (1 quadrat)
- *EmChKaDhXpAI* (1 quadrat)

About 16.6 ha of the *EmChXoBgRcDnSIHhSwDI* mapping unit which is associated with areas of moderately deep yellow or orange sand (otherwise with a total area within the mining leases of 27 ha would be disturbed during the proposed mining. A survey by Smith (2008a) located a further 69 ha of vegetation corresponding with the description of mapping unit *EmChXoBgRcDnSIHhSwDI* (the “orange” or “yellow” sands community) in State forest adjacent to the southern boundary of the Happy Valley mining leases. The Department of Environment and

Conservation has requested additional quantitative information on the impact of mining proposals by Bemax Resources on the regional distribution of the C2 community.

## 2. DEFINING FCT C2

### 2.1.1. The Whicher Scarp survey

The Whicher Scarp floristic community type C2 is in effect “defined” by the list of typical and common species listed on page 178 of Keighery *et al.* (2008) (Table 1). Apart from the floristics of FCT C2 the other factors which help to define it are its geographic location (the Whicher Scarp landform and immediately adjacent parts of the Swan Coastal Plain) and soil characteristics (deep, generally coloured colluvial sand, rarely associated with laterites).

The species listed for FCT C2 by Keighery *et al.* (2008), particularly the “typical” species, that is those occurring in 75% or more of the 8 quadrats designated as FCT C2 can be thought of as “indicator species” (*sensu* Havel, 1975a, b; Strehlein, 1988) or “constant or diagnostic” species (U.S.G.S. and N.P.S, 2008). FCT C2 has the strongest representation of “common sand taxa” in Floristic group C, especially *Hypolaena exsulca*, *Dasyogon bromeliifolius*, *Stirlingia latifolia*, *Petrophile linearis*, *Melaleuca thymoides* and *Adenanthos meisneri* which form part of species group 24/50/92 (Keighery *et al.*, 2008).

Typical Species (> 75% of sites)	Common species (50-75% of sites)	Common species (50-75% of sites)
<i>Banksia dallanneyi</i>	<i>Acacia extensa</i>	<i>Gompholobium polymorphum</i>
<i>Burchardia congesta</i>	<i>Acacia stenoptera</i>	<i>Gompholobium preissii</i>
<i>Chamaescilla corymbosa</i>	<i>Adenanthos barbiger</i>	<i>Grevillea trifida</i>
<i>Conostylis setigera</i>	<i>Adenanthos meisneri</i>	<i>Hakea ruscifolia</i>
<i>Desmocladius fasciculatus</i>	<i>Amphipogon amphipogonoides</i>	<i>Hibbertia acerosa</i>
<i>Eucalyptus marginata</i>	<i>Anarthria prolifera</i>	<i>Hibbertia commutata</i>
<i>Gompholobium knightianum</i>	<i>Banksia grandis</i>	<i>Hibbertia quadricolor</i>
<i>Hibbertia cunninghamii</i>	<i>Billardiera variifolia</i>	<i>Hypolaena exsulca</i>
<i>Hibbertia hypericoides</i>	<i>Boronia dichotoma</i>	<i>Hypolaena robustum</i>
<i>Hovea trisperma</i>	<i>Corymbia haematoxylon</i>	<i>Isopogon sphaerocephalus</i>
<i>Labichea punctata</i>	<i>Dampiera linearis</i>	<i>Lomandra sonderi</i>
<i>Lepidosperma squamatum</i>	<i>Dasyogon hookeri</i>	<i>Pentapeltis peltigera</i>
<i>Lomandra hermaphrodita</i>	<i>Daviesia divaricata</i>	<i>Petrophile linearis</i>
<i>Lomandra sericea</i>	<i>Drosera pallida</i>	<i>Stirlingia latifolia</i>
<i>Patersonia umbrosa</i>	<i>Eriochilus dilatatus</i>	<i>Stylidium amoenum</i>
<i>Tetraria octandra</i>	<i>Gompholobium confertum</i>	<i>Styphelia tenuiflora</i>
	<i>Gompholobium marginatum</i>	<i>Xylomelum occidentale</i>

**Table 1.** Lists of “Typical” and “Common” species for the Whicher Scarp Floristic Community Type “Whicher Scarp Jarrah woodland of deep coloured sands” (FCT C2). (Keighery *et al.* 2008)

Floristic group C, to which FCT C2 belongs, consists of 49 of the 124 quadrats used in the Whicher Scarp study of Keighery *et al.* (2008). In addition to FCT C2 there were five other community types identified for Group C. Floristic Group C is typically associated with laterite or coloured sands and, except for 3 quadrats on the Swan Coastal Plain within 2 km of the

scarp, is confined to the Whicher landform. Keighery *et al.* reported that patterning was evident in Group C, but generally the community types were poorly differentiated, “being separated by a greater frequency of some common and less common sand taxa in community types C1 and C2, and a greater frequency of laterite favoring taxa in types C3 to C6”.

While FCTs C1 and C2 are mainly found on deeper sand and have a relatively high abundance of “sand taxa” two of the other floristic groups identified by the Whicher survey, Groups A and B, are also found on sand within the Whicher Scarp landform. Tables 2 summarizes the main distinguishing features in terms of geographical position and soil between Floristic Groups A and B and FCTs C 1 and C2 and Table 3 .

Floristic Unit	Landform	Soil colour
Floristic Group A (23 quadrats)	Mid-slopes (12) and Lower Slopes (6) of the Whicher Scarp; Swan Coastal Plain (3)	White/Grey sand (18); Coloured (5)
Floristic Group B (22 quadrats)	Swan Coastal Plain (12); Whicher Scarp Mid-Slopes (5); Lower Slopes (3); Blackwood Plateau (1)	White/Grey (22)
FCT C1 (10 quadrats)	Whicher Scarp Lower Slopes (3), Mid-slopes (3), Upper Slopes (2) and Riverine (1); Swan Coastal Plain (1)	Coloured (8); White/Grey (2)
FCT C2 (8 quadrats)	Whicher Scarp Mid-slope (5) and Upper Slopes (1); Swan Coastal Plain (2)	Coloured (6); White/Grey (2)

**Table 2.** Summary table of distribution by landform and soil colour of Floristic Groups A and B and Floristic Community Types C1 and c2 of the Whicher Scarp survey (Keighery *et al.*, 2008).

### ***2.1.2. The Happy Valley mining lease floristic surveys***

In order to determine the relationships of the vegetation on the Happy Valley mining leases Griffin (2008) subjected the floristic data from 61 quadrats established on and adjacent to the leases by Bennett Environmental Consulting (2007) and 103 quadrats drawn from the Swan Coastal Plain (Gibson *et al.*, 1994) and Whicher Scarp surveys to multivariate analysis. Happy Valley quadrats were placed within the floristic community types defined by Keighery *et al.* (2008) by inferring that they belonged to the Whicher study FCTs that they were closest to on the dendrogram produced following Semi-strong Hybrid Scaling ordination and Hierarchical (Agglomerative) Clustering using the software PATN.

Nineteen of the 61 quadrats were assigned to FCT C2 by Griffin, using a combination of the classification dendrogram and nearest neighbor analysis. Most of the Happy Valley C2 quadrats had good “similarity values” – which measure the degree of similarity of samples sets – in this case between the Happy Valley quadrats and those from the Whicher survey. The most common species within the Happy Valley quadrats assigned to FCT C2 are presented in Table 4.

Typical/Common and widespread in Floristic Group A but not FCT C2	Typical/Common in FCT B1 but not in FCT C2	Typical/Common in FCT C1 but not in FCT C2	Typical/Common in FCT C2 but not in FCT C1
<i>Acacia pulchella</i> <u><i>Banksia attenuata</i></u> <i>Bossiaea eriocarpa</i> <u><i>Calothamnus sanguineus</i></u> <i>Conostephium pendulum</i> <u><i>Dasyopogon bromeliifolius</i></u> <u><i>Gompholobium capitatum</i></u> <i>Hypocalymma robustum</i> <u><i>Melaleuca thymoides</i></u> <i>Mesomelaena tetragona</i> <i>Nuytsia floribunda</i> <i>Patersonia occidentalis</i> <i>Philothea spicata</i> <i>Phlebocarya ciliata</i> <i>Pimelea rosea</i> <i>Scaevola calliptera</i> <u><i>Xanthorrhoea preissii</i></u>	<i>Acacia pulchella</i> <u><i>Banksia attenuata</i></u> <u><i>Bossiaea eriocarpa</i></u> <i>Calytrix flavescens</i> <u><i>Conostephium pendulum</i></u> <u><i>Dasyopogon bromeliifolius</i></u> <i>Gompholobium tomentosum</i> <u><i>Hibbertia vaginata</i></u> <i>Jacksonia horrida</i> <i>Leucopogon conostephioides</i> <u><i>Lyginia barbata</i></u> <u><i>Melaleuca thymoides</i></u> <u><i>Patersonia occidentalis</i></u> <u><i>Philothea spicata</i></u> <u><i>Phlebocarya ciliata</i></u>	<i>Agrostocrinum hirsutum</i> <i>Boronia crenulata</i> <u><i>Bossiaea ornata</i></u> <i>Calothamnus sanguineus</i> <i>Cyathochaeta equitans</i> <u><i>Hakea amplexicaulis</i></u> <i>Hakea cyclocarpa</i> <i>Hibbertia diamesogenos</i> <u><i>Hibbertia glomerata</i></u> <i>Hovea chorizemifolia</i> <i>Hypocalymma robustum</i> <i>Kingia australis</i> <i>Loxocarya cinerea</i> <i>Mesomelaena tetragona</i> <i>Philothea spicata</i> <i>Sphaerolobium medium</i> <i>Tetraria capillaris</i> <i>Tetratheca hirsuta</i>	<i>Adenanthos meisneri</i> <i>Amphipogon amphipogonoides</i> <i>Billardiera variifolia</i> <i>Boronia dichotoma</i> <i>Corymbia haematoxylon</i> <i>Daviesia divaricata</i> <i>Gompholobium confertum</i> <i>Gompholobium marginatum</i> <i>Gompholobium preissii</i> <i>Grevillea trifida</i> <i>Hakea ruscifolia</i> <i>Hibbertia acerosa</i> <i>Hibbertia commutata</i> <i>Hypolaena robustum</i> <i>Petrophile linearis</i> <i>Stirlingia latifolia</i> <i>Styphelia tenuiflora</i> <i>Xylomelum occidentale</i>

**Table 3.** Differential species between the Whicher Scarp and adjacent Floristic Groups and Floristic Community Types that are predominantly found on deep or moderately deep sand (Based on Keighery *et al.*, 2008). Note 1: Only perennial species are included. Note 2: Underlined species for Group A occur in three or more of the FCTs in that Group, underlined species in FCTs B1 and C1 are those that are typical for that FCT (> 75% of quadrats). Note 3. With regard to Floristic Group B only FCT B1 is included, FCT B2 consists of only one quadrat located at the western end of the Whicher Scarp.

"Typical" species (> 75% of quadrats)	"Common" species (50 – 75% of quadrats)
<i>Adenanthos barbiger</i>	<i>Acacia extensa</i>
<i>Banksia dallanneyi</i>	<i>Anarthria prolifera</i>
<i>Banksia grandis</i>	<b><i>Boronia humifusa</i></b>
<i>Boronia dichotoma</i>	<b><i>Daviesia nudiflora</i></b>
<i>Conostylis setigera</i>	<i>Drosera pallida</i>
<i>Corymbia haematoxylon</i>	<b><i>Drosera stolonifera</i></b>
<i>Dasyogon hookeri</i>	<i>Hakea ruscifolia</i>
<i>Desmocladus fasciculatus</i>	<b><i>Hibbertia huegelii</i></b>
<i>Eucalyptus marginata</i>	<i>Hypolaena exsulca</i>
<i>Gompholobium knightianum</i>	<b><i>Melaleuca thymoides</i></b>
<i>Hibbertia acerosa</i>	<i>Petrophile linearis</i>
<i>Hibbertia amplexicaulis</i> <sup>2</sup>	<b><i>Synaphea whicherensis</i></b>
<i>Hibbertia hypericoides</i>	<i>Tetraria octandra</i>
<b><i>Hypocalymma robustum</i></b>	<i>Xylomelum occidentale</i>
<i>Isopogon sphaerocephalus</i>	
<i>Lomandra hermaphrodita</i>	
<i>Lomandra sericea</i>	
<i>Pentapeltis peltigera</i>	
<i>Stirlingia latifolia</i>	
<b><i>Stylidium ciliatum</i></b>	
<b><i>Xanthorrhoea gracilis</i></b>	
<b><i>Tetraria capillaris</i></b>	

**Table 4.** List of "Typical" (occurring in > 75% of quadrats) and "Common" (50 - 75% of quadrats) species for the 19 quadrats from the Happy Valley dataset assigned to FCT C2 by Griffin (2008). Taxa in bold were not among the "typical" or "common" species for FCT C2 in Keighery et al. (2008).

Not surprisingly, considering that the Happy Valley quadrats were concentrated in a 17 km long stretch of the Whicher Scarp, compared to the 67 km distance along the scarp between the most north easterly and most westerly FCT C2 quadrats of Keighery *et al.*, there is a substantial difference in "typical" and "common" species between tables 1 and 4. The "typical" species for FCT C2 from the Whicher Survey that were not "typical" or "common" in the Happy Valley dataset were *Burchardia congesta*, *Chamaescilla corymbosa*, *Hovea trisperma*, *Labichea punctata*, *Lepidosperma squamatum*, *Patersonia umbrosa* and *Tetraria octandra*. However, all these species were present in the Happy Valley dataset, at a lower frequency.

Considering the high species richness ( $\alpha$ -diversity) and rapid species turnover ( $\beta$ -diversity) of the Whicher Scarp and adjacent Swan Coastal Plain (Keighery *et al.*, 2008; Gibson *et al.*, 1994) it is not surprising that a somewhat different group of taxa emerge as the most frequent (or "faithful") within the FCT C2 community between the Whicher Survey that covers a 67 km

<sup>2</sup> Note: It is assumed here that "*Hibbertia cunninghamii*" from the Whicher survey and "*Hibbertia amplexicaulis*" from the Happy Valley surveys refer to the same species.

length of the scarp but is only represented by 8 quadrats and the Happy Valley survey which extends over only 25% of the that distance with 19 quadrats classified as FCT C2. Unfortunately, the data from the Whicher Survey was not available to be used in preparing this report so it is not possible to prepare a “composite” list of “typical” and “common” species for FCT C2 from the raw data from both studies. However the species listed in Table 5 appear in both tables 1 and 4 as typical or common species for FCT C2 and therefore can be viewed as an interim list of diagnostic taxa for the community.

Species	Differential species from FCT C1
<i>Acacia extensa</i>	
<i>Adenanthos barbiger</i>	
<i>Anarthria prolifera</i>	
<i>Banksia dallanneyi</i>	
<i>Banksia grandis</i>	
<i>Boronia dichotoma</i>	X
<i>Corymbia haematoxylon</i>	X
<i>Dasypogon hookeri</i>	
<i>Desmocladius fasciculatus</i>	
<i>Drosera pallida</i>	
<i>Eucalyptus marginata</i>	
<i>Gompholobium knightianum</i>	
<i>Hakea ruscifolia</i>	X
<i>Hibbertia acerosa</i>	X
<i>Hibbertia amplexicaulis</i>	
<i>Hibbertia hypericoides</i>	
<i>Hypolaena exsulca</i>	
<i>Isopogon sphaerocephalus</i>	
<i>Lomandra hermaphrodita</i>	
<i>Lomandra sericea</i>	
<i>Pentapeltis peltigera</i>	
<i>Petrophile linearis</i>	X
<i>Stirlingia latifolia</i>	X
<i>Tetraria octandra</i>	
<i>Xylomelum occidentale</i>	X

**Table 5.** List of diagnostic species for FCT C2 drawn from the Whicher Survey (Keighery et al., 2008) and the Happy Valley surveys (Bennett Environmental Consulting, 2007). These taxa were present in 50% or more of FCT C2 quadrats for both surveys. Species marked with a “X” are those that do not occur in 50% or more of quadrats for FCT C1, floristically the closest community to FCT C2.

A working definition of FCT C2 is therefore;

“A vegetation unit found on deep “coloured” (yellow-grey, yellow-brown, red-brown) or occasionally grey-white sandy soils of the Whicher Scarp and adjacent Swan Coastal Plain that contains a high percentage of the species listed in Table 5 above.”

Of course it should not be assumed that taxa listed in Table 5 are always the dominant species in any given stand of FCT C2 vegetation. A survey by Smith (2008a) of coloured sandy soils in State forest immediately south of the Happy Valley mining leases found that *Daviesia nudiflora*, *Hakea ruscifolia*, *Ricinocarpos cyanescens* and *Synaphea whicherensis* were the characteristic species of the FCT C2 community, and also that *Banksia attenuata*, which according to Table 3 is a differential species between Floristic Group A and FCT B1 and FCT C2, was present in 38% of FCT C2 relevés.

## 2.2. The distribution of FCT C2

Keighery *et al.* (2008) show the distribution of FCT C2 as occurring from Boyanup Block 19 km SE of Bunbury to Acton Park Nature Reserve 62 km SW of Bunbury (Fig. 1). Five of these eight FCT C2 quadrats from the Whicher Scarp study occur between the Ludlow and Preston Rivers in Argyle and Happy Valley State forest blocks. As explained above, Griffin (2008) assigned 19 of the quadrats from the Happy Valley surveys, the location of these quadrats is included in Fig. 1 below.

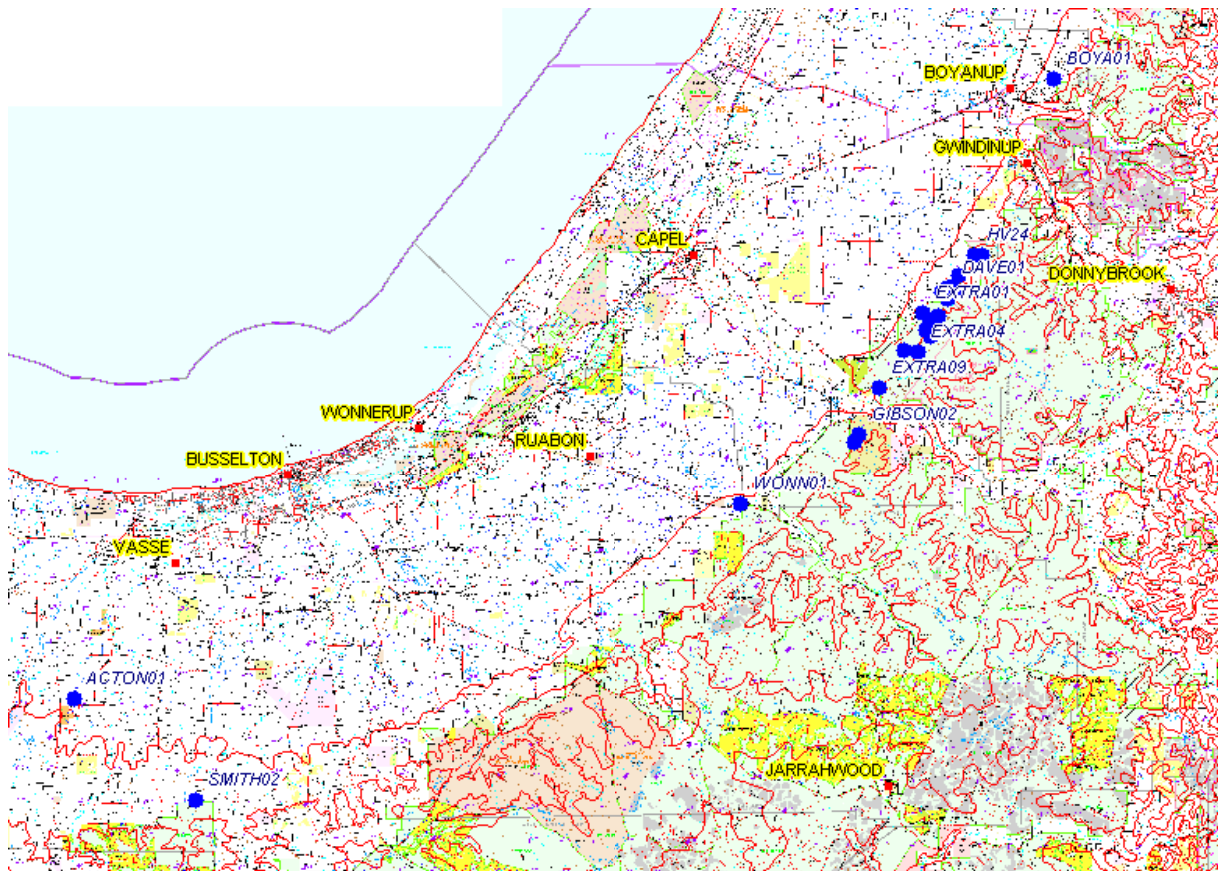


Figure 1. Location of FCT C2 quadrats from Whicher Survey (Keighery *et al.*, 2008) and Happy Valley surveys (Bennett Environmental Consulting, 2007).

### **2.3. Comparison of Whicher FCT C2 with FCTs from the Swan Coastal Plain survey**

Keighery *et al.* (2008) state that Whicher Scarp Floristic Community Group C is virtually equivalent to Swan Coastal Plain FCT 1a (Gibson *et al.*, 1994). Three of the quadrats within group C are on the coastal plain (Abba Plain soil-landscape sub-region) and one of the quadrats from Swan Coastal Plain (SCP) FCT 1a was also situated on the Abba Plain. Griffin (2008) and Smith (2008b) also noted the floristic similarities between some quadrats located on the Whicher Scarp and others located up to one kilometre from the scarp on the Abba Plain soil-landscape sub-system.

Smith's floristic analysis, which unlike that of Keighery *et al.* included woodland quadrats from the heavy soils of the Swan Coastal Plain, showed that the pattern of floristic groups formed following multivariate analysis varied markedly from that of the Whicher Survey report<sup>3</sup>. Two conclusions that can be drawn from the work of Smith (2008b) are;

- A. Some of the quadrats placed by the Whicher Survey report in FCT C2 (e.g. ACTON-1 and WONN-1) group more closely with FCT C1 quadrats such as ACTN02 and KEMPO1 than they do with the orange soil sites of the Happy Valley mining leases and in Argyle Forest Block (which are also placed within C2)<sup>4</sup>,
- B. Other Whicher FCT C2 (smith02) and C1 (GOUL01) quadrats group much more closely with quadrats from Swan Coastal Plain FCT 1b ("Southern Marri woodlands on heavy soils") and the creekline quadrats and quadrats on heavier soils from the Happy Valley surveys (that Griffin found difficult to place within Whicher Scarp FCTs) than they do with the FCT C1 and C2 quadrats mentioned in A, above.

It is likely that a re-analysis of the Swan Coastal Plain data of Gibson *et al.* (1994) and subsequent work by the Department of Environmental Protection (DEP, 1996) together with the Whicher Scarp floristic data of Keighery *et al.* (2008) and Bennett and others would lead to new insights into the relationships of Whicher Scarp and SCP vegetation.

## **3. OBJECTIVES**

The objective of the survey reported here is, in the light of DEC's concerns about its conservation status and how this might be affected by the proposed mining at the Happy Valley leases, to increase the level of knowledge about the distribution and extent of Whicher Scarp FCT C2. Specifically it is to produce a report that, based on previous published and unpublished reports and field work carried out as part of the project, provides information on the estimated current extent of the community and its approximate boundaries.

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<sup>3</sup> The data for the Whicher Scarp of Keighery *et al.* (2008) was not made available for this analysis.

<sup>4</sup> Both ACTON-1 and ACTN02 are on the Swan Coastal Plain.

## 4. METHODS

The distribution of floristic quadrats determined to belong to FCT C2 by the Whicher and Happy Valley surveys was used as a starting point for this project. The sites or general locations of all of these except those within the mining leases and within the area surveyed by Smith (2008) were visited during the current survey. In addition other likely areas along the scarp between Boyanup and Treeton State forest blocks were searched.

The method used to determine the boundaries of the community in areas where there are quadrats determined to be FCT C2, and to select likely new areas of FCT C2 was based on a rapid survey technique developed for the project. At each site where an FCT C2 quadrats occurred, and in other sites that appeared to contain the community, the area was traversed on foot. Using the presence of “coloured” soils and a selected set of diagnostic species drawn from those presented in Table 5, plus others considered useful in certain areas (e.g. *Daviesia nudiflora*) approximate boundaries were determined in the field and their locations recorded using a GPS unit. In addition at certain points a list of dominant and diagnostic species was recorded within a “releve” of approximately 20 x 20 m. Because of the time of the survey (early February) most annual or annually-renewed species could not be seen. However, Griffin (2008) found that, in general, the presence of annuals in the analysis to determine FCTs made little difference.

## 5. RESULTS

The boundaries of known and newly discovered occurrences of FCT C2 are depicted in Figs. 2-7. The accuracy of these boundaries varies somewhat. Lack of time limited the delineation of boundaries in Happy Valley block especially and those shown give a conservative estimate of the actual area. In addition, the occurrence within the Happy Valley north mining lease is probably an underestimate of the actual area.

Boundaries of FCT C2 were difficult to determine in Treeton State forest block because of the unusual vegetation and species composition in this area where the occurrence borders areas of “Busselton Ironstones” and “Southern Marri woodlands on heavy soils” Swan Coastal Plain floristic community types.

A total of 22 occurrences of FCT C2 were mapped, ranging in area from 0.9 ha to 77 ha to give a total area for the community of 294 ha. For the reasons mentioned above this is probably an underestimate. The individual occurrences, size, general location, soil mapping unit and altitudinal range is given in Table 6.

Occurrence	Area (ha)	Location and tenure*	Soil Mapping Unit	Altitude (mAHD)
1	8.8	Boyanup Block (SF)	214WswC2	70-80 m
2	0.9	Boyanup Block (SF)	214WswC2	85-90 m
3	14.5	Argyle Block (SF)	214WswC2/214GvRO3	90-110 m
4	3.6	Argyle Block (SF)	214GvRO3	80-95 m
5	76.8	Argyle Block (SF)	214WswC2	85-110 m
6	41.9	Argyle Block (SF)	214WswC2	60-80 m
7	0.7	Argyle Block (SF)	214WswC2	80-85 m
8	37.4	Happy Valley Block (SF)	214WswYL/214WswCv/214WswC2	90-100 m
9	4.2	Happy Valley Block (SF)	214WswC2	85-95 m
10	1.7	Happy Valley Block (SF)	214WswC2	95-100 m
11	1.3	Happy Valley Block (SF)	214GvPR/214GvRO3	75 m
12	1.7	Happy Valley Block (SF)	214WswC2	100 m
13	14.4	Abba Block (SF)	213FoCSs/214WswYL3/214GvPR	58-63 m
14	1.8	Abba Block (SF)	213FoCSs/214WswYLd	57-62 m
15	2.2	Abba Block (SF)	213FoCSs	57-62 m
16	5.4	Argyle Block (SF)	214GvRO3	55-70 m
17	4.4	Argyle Block (SF)	214GvRO3	65-75 m
18	1.3	Jindong School (LGR)	213AbJdf	38 m
19	2.6	Treeton Block (SF)	214WswYL1	75 m
20	2.1	Treeton Block (SF)	214WswYL1/214WswYL2	65 m
21	60.0	HVS mining lease (PP/SF)	214WswC2/214WswCv/214GvRO3	80-120 m
22	6.5	HVN mining lease (SF)	214WswC2	110-130 m
Total area	294.2			

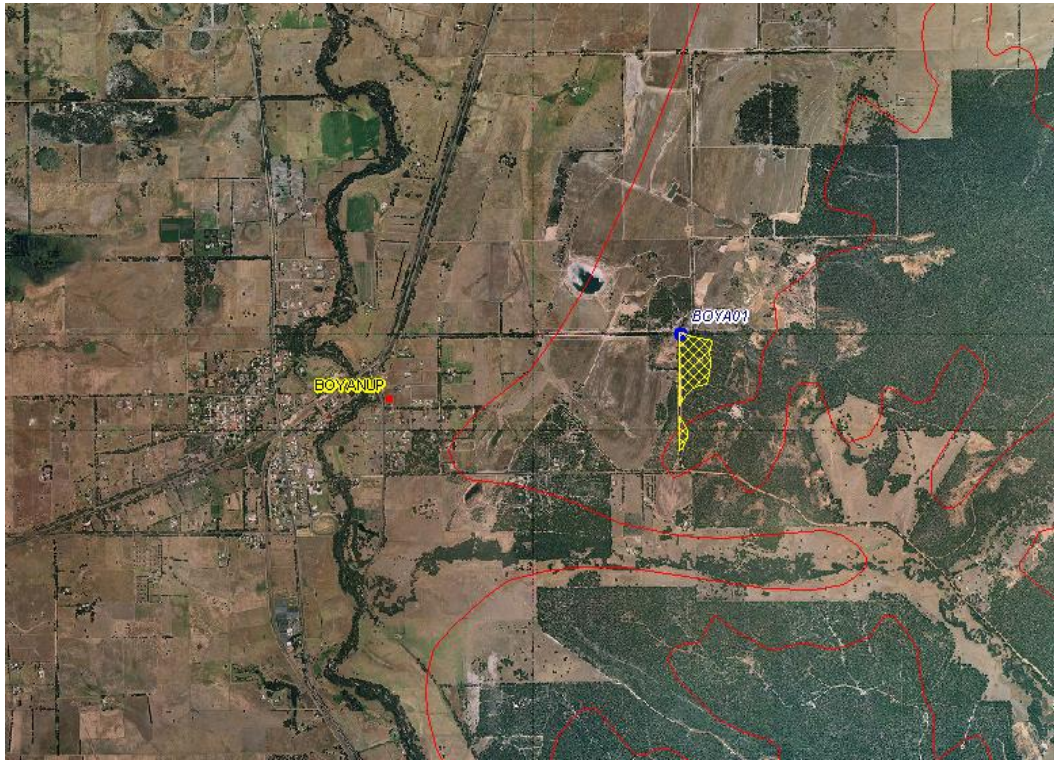
**Table 6.** Area, location, soil unit and altitudinal range of 23 occurrences of FCT C2. Tenure codes: SF: State forest, LGR: Local government reserve, PP: Private property. (Approx. 25 ha of the Happy Valley South mining lease occurrence is in State Forest, with the remainder on Private Property).

## 6. LIMITATIONS OF THIS SURVEY

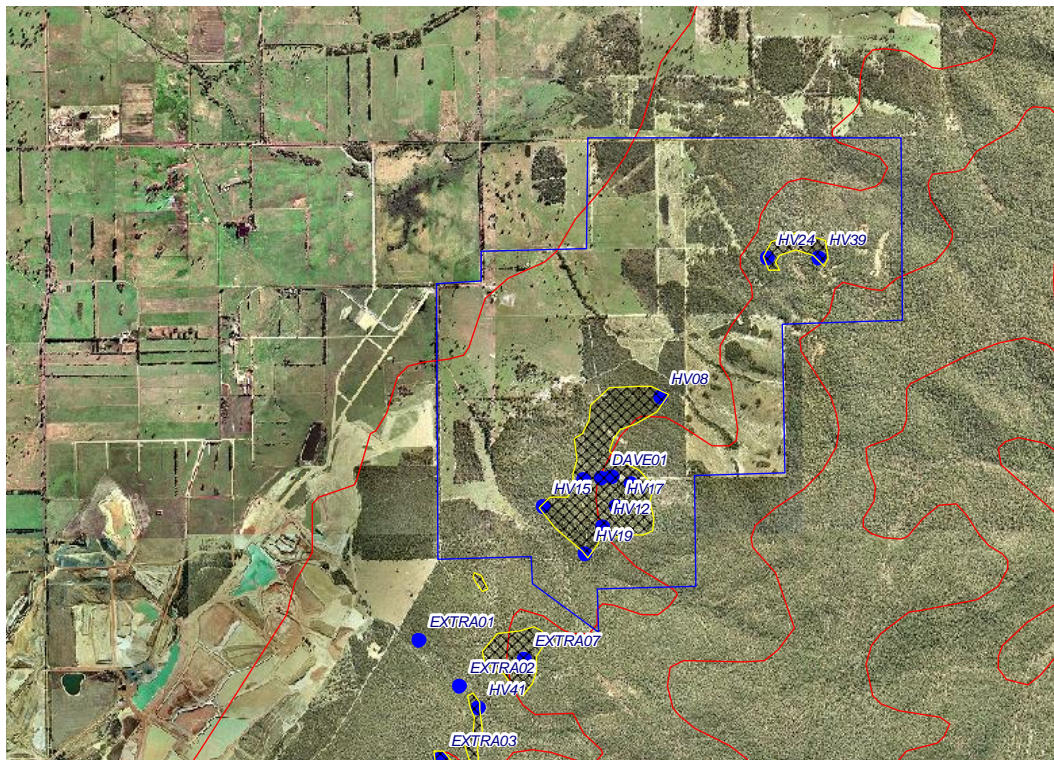
There were several limitations that may have influenced the results of the survey, analysis and conclusions presented here;

1. The survey to determine the extent of currently known and new occurrences of FCT C2 was carried out in summer and therefore the annual or annually-renewed taxa that characterize the community could not be used in locating occurrences or defining boundaries. However, Griffin (2008) found that the inclusion or exclusion of annuals made little difference to the assignment of quadrats to FCTs,
2. The floristic data of Keighery *et al.* (2008) was not made available for this project so the raw data reported on in that work could not be used to refine the list of diagnostic species for FCT C2, or to re-assess the relationships between Whicher Scarp and SCP communities,
3. There were some time limitations on the survey to determine the extent of FCT C2 communities. The areas presented in Table 6 should be viewed as a conservative estimate of the actual area of this floristic community,
4. As mentioned above the boundaries of FCT C2 were difficult to delineate in the field at some locations, particularly Treeton Forest Block, where the community blended into neighbouring types with no clear boundary,
5. No attempt was made to remap the extent of FCT C2 within the Happy Valley mining leases area. The boundaries of mapping unit *EmChXoBgRcDnSIHhSwDI* and areas of mapping units *EmAfChMtHh* and *EmAfChBaBgDhMtSIHhPc* proximate to quadrats designated as C2 were used to delineate the community. The latter two mapping units contain areas that are FCT C2, but also areas that clearly belong to other communities.

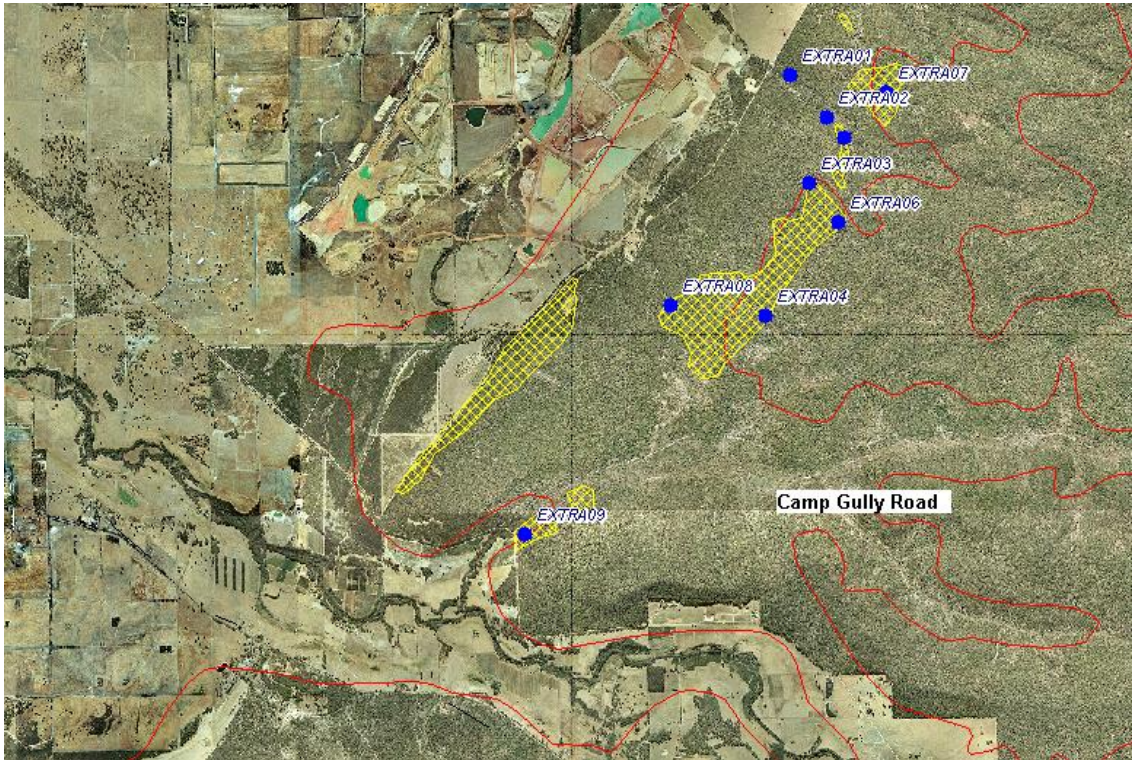
6.



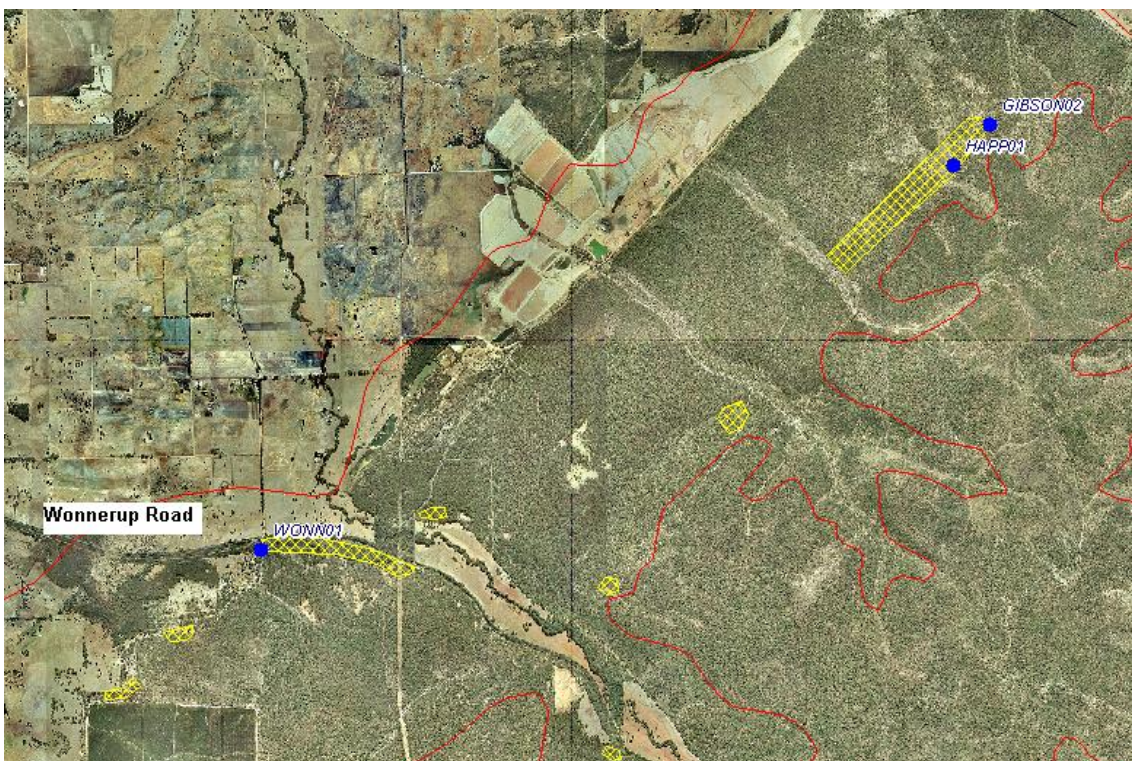
**Figure 2.** Occurrences of FCT C2 in Boyanup State forest block.



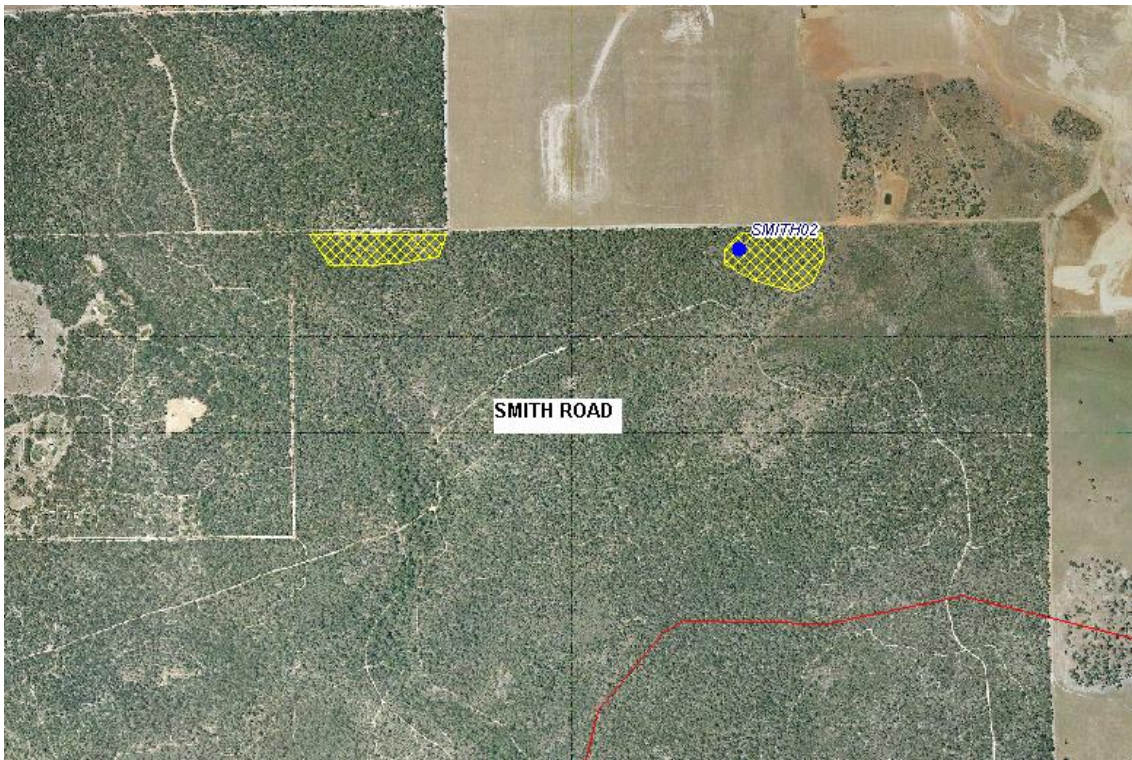
**Figure 3.** Occurrences of FCT C2 in the Happy Valley mining leases (blue line) and adjacent areas of Argyle State forest block.



**Figure 4.** Occurrences of FCT C2 in Argyle State forest block south of Happy Valley mining leases.



**Figure 5.** Occurrences of FCT C2 in Happy Valley and the northern part of Abba State forest blocks.



**Figure 6.** Occurrences of FCT C2 in Treeton State forest block.



**Figure 7.** Occurrence of FCT C2 in the old Jindong school reserve on Payne Road.

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