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Aquatic &
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Technical Memorandum

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Subject: Mapping of Groundwater Dependent Ecosystems (GDEs), response to PA2024/0006 Letter of Deferral - NT Portion 1188, Claravale Farm, Claravale and Deferral of application to clear native vegetation on Pastoral land – NT Portion 1169, Claravale Station, PPL 1214.

Background

Clearing applications were submitted for NT Portion 1188, Claravale Farm and NT Portion 1169, Claravale Station, PPL1214. Subsequently, deferral letters were received requesting additional information on several aspects of the applications. This memo addresses item 1 of the deferral letter for Claravale Farm (provided below) by mapping and assessing potential GDEs using multiple lines of evidence. The assessment was also undertaken for Claravale Station, to address concerns raised in the public submissions, although not specifically itemized in the deferral letter.

“1. Clause 3.2.5(a) – avoid impacts on environmentally significant or sensitive vegetation

The application has not adequately identified two groundwater dependent ecosystems (GDE’s) (obligate phreatophytes and seasonally facultative phreatophyte), associated with the Daly River and its floodplain.

Vegetation communities that are dependent on groundwater are considered as significant and/or sensitive vegetation for the purposes of the Northern Territory Planning Scheme 2020. The Northern Territory Planning Scheme Land Clearing Guidelines (NTPS LCG) recommended that clearing of GDE’s is avoided and that an appropriate native vegetation buffer is adopted.

It is recommended that detailed mapping of the location and extent of obligate phreatophytes and seasonally facultative phreatophyte (prepared by a suitably qualified person) is provided. The suitably qualified person should also provide an assessment of the value of these GDE’s when assessed against the criteria in Section 4.4.8 of the NTPS LCG. That assessment should propose native vegetation buffers within, and adjacent to, the application footprint so as to avoid impacts to GDE’s.”

Approach

A desktop assessment was undertaken using several lines of evidence to map potential GDEs. These included layers from the National GDE Atlas, NDVI imagery derived from the Sentinel satellite, and depth to groundwater from co-located bores, if available. The value of the potential GDEs were then assessed as per the criteria in Section 4.4.8 of the NTPS LCG, and appropriate buffers proposed.

Depth to water is often used as an initial check to see if vegetation could be accessing groundwater during all or some of the year. A water table depth of 20 meters is considered a critical cut-off for plants accessing groundwater (NTPS LCG) because most plant roots do not extend to such depths. Typically, plant root systems are adapted to access water and nutrients within the upper soil layers, with the majority of roots found within the top few meters of soil. Only certain deep-rooted plants, such as some species of trees, have the capability to reach groundwater at depths beyond 20 meters. Therefore, when the water table drops below this threshold, it becomes inaccessible to the majority of vegetation.

The National GDE Atlas was developed by the Australian government using a GIS mapping approach and used broad scale spatial data (some developed using remote sensing) to map potential GDEs. The spatial data layers differed regionally as consistent datasets across the whole of Australia were few. The reliability of the predicted GDEs was directly related to the data quality and availability for a given region and reports describing the Atlas development method highlight multiple data deficiencies for large regions of the country (Doody et al., 2017; Dowsley et al., 2012). Due to these limitations, the Atlas defines areas of 'potential' GDEs rather than specific spatial delineation of individual GDE ecosystems. Nevertheless, the Atlas can provide an appropriate starting place to assess potential GDEs.

An alternative approach of identifying GDEs using remote sensing can provide a higher resolution of mapping and is more likely to be able to directly detect GDEs rather than just the inferring potential for their existence. The increased availability of satellite imagery has seen an increase in studies which use this approach (Alaibakhsh et al., 2016; Barron et al., 2012; Gou et al., 2015; Huntington et al., 2016; Münch and Conrad, 2007; Pérez Hoyos et al., 2016). Remote sensing methods are based on a conceptual understanding of the ecohydrological interactions within a landscape and the effect of these interactions on the spectral signature captured via remote sensing (Barron et al., 2012; Glanville et al., 2016). For example, 'greenness', as measured by remotely sensed vegetation indices (VIs), is commonly used to infer water availability to vegetation. Identifying GDEs with VIs utilises the concept that vegetation which is accessing groundwater will be able to maintain productivity during dry periods and therefore show characteristics associated with high photosynthetic activity, moisture content and biomass (O'Grady et al., 2011; Pérez Hoyos et al., 2016; Tweed et al., 2007). The most commonly used vegetation index for these types of studies is the Normalised Difference Vegetation Index (NDVI), which is calculated from the red edge formed by reflectance in the red and near infrared (NIR) wavelengths and is sensitive to greenness (Townshend and Justice, 1986; Tucker, 1979).

NDVI values range from -1 to +1. Values close to +1 typically indicate high levels of vegetation with healthy, dense plant life, suggesting high photosynthetic activity. As the values decrease towards zero and below, they reflect lower plant density and health, typically corresponding to sparse vegetation or non-vegetated surfaces such as rocks, rooftops, or barren lands. Negative values near -1 are often associated with water bodies, indicating very low or no vegetative productivity.

For this mapping exercise, rainfall records were interrogated from BOM station 014902 - Katherine Council (the closest station with adequate rainfall record) to identify below average wet seasons or years where the dry season was particularly long (e.g. 6 full months with no rainfall). A Sentinel-2 satellite image (L2A, 10m resolution, pre-processed for NDVI) was then selected to coincide with the latest data capture prior to wet season onset. **Figure 1** shows the monthly rainfall totals and water year (Aug – Sept) totals from 2015-2024 (Sentinel data captures commenced in 2015). The selected Sentinel image was captured on 13 November 2019 after a long dry season (217 day without rain, ~7 months) and a below average prior wet season. The rationale for image selection is based on the concept that areas that are still ‘green’ after extended dry periods, are likely accessing groundwater to maintain productivity.

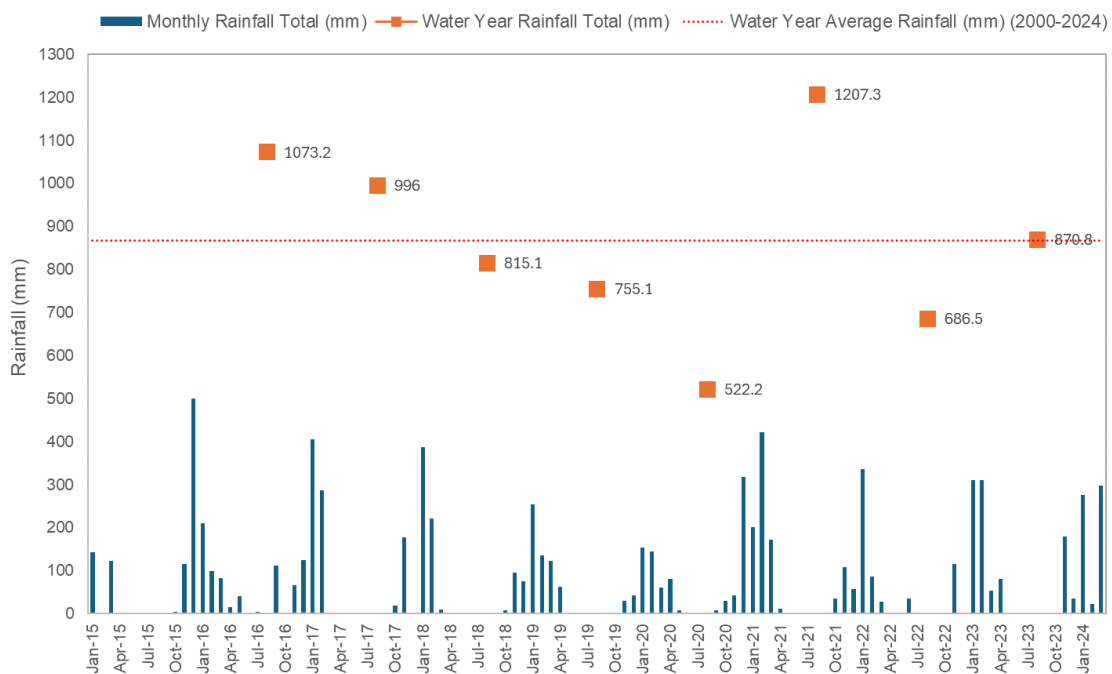


Figure 1. Monthly rainfall and water year (Sept-Aug) rainfall for BOM station 014902 – Katherine Council

The value of the identified GDEs was assessed according to guidance provided in *Section 4.4.3 Biodiversity Risk Assessment* and *Section 4.4.8 Wetlands and Groundwater Dependent Ecosystems* of the Northern Territory Planning Scheme Land Clearing Guidelines (NTPS LCG). Records of threatened and significant species, and details of conservation areas were downloaded from NR Maps (Northern Territory Government, 2024).

Results

NT Portion 1188, Claravale Farm

Claravale Farm borders the Daly River to the south and the west. The Daly River is perennial with baseflow supported by groundwater (Smerdon et al. 2012). The width of riparian vegetation bordering the Daly River varies along its length, with larger areas often associated with confluences, small drainage lines or nearby off stream waterbodies. Dead Horse Creek, a tributary of the Daly River, dissects Claravale Farm, draining from the northern boundary into the Daly in the southwest. Dead Horse Creek is non-perennial, drying during the dry season.

Spatial layers from the GDE Atlas show potential GDEs located within and adjacent to the Claravale Farm cadastral boundary (**Figure 2A**). These include both aquatic and terrestrial GDEs. The aquatic GDEs include a permanent waterhole near the Daly River on the western side of the property, a smaller waterhole to the south, and the drainage lines associated with the Daly River and Dead Horse Creek. The terrestrial GDEs include the narrow strip of riparian vegetation bordering the Daly River and along drainage depressions on the bank opposite the farm.

The NDVI imagery (**Figure 2B**) generally corroborates the Atlas mapping, however, refines it and indicates additional areas which are likely groundwater dependent ecosystems. This includes the drainage depression in the west, the drainage depression south of the permanent waterhole, and around the confluence of Dead Horse Creek.

Only two bores were available to assess depth to water across the farm. The closest bore (RN034900) is located south of the Daly River, ~60m from the bank. Standing water level (SWL) was recorded 11 times from 2005 to 2015 (most often in the late dry season) and ranged from -15.56 mbgl to -18.66 mbgl, indicating the potential for vegetation to access the groundwater. It is likely groundwater is at a similar depth in most areas near the river. The second bore (RN007509) is located on the northern boundary of the farm with SWL recorded twice in 2001 and 2005. SWL ranged from -43.75 mbgl to -44.18 mbgl and indicates depth to groundwater in excess of those generally accepted as readily accessible to plants.

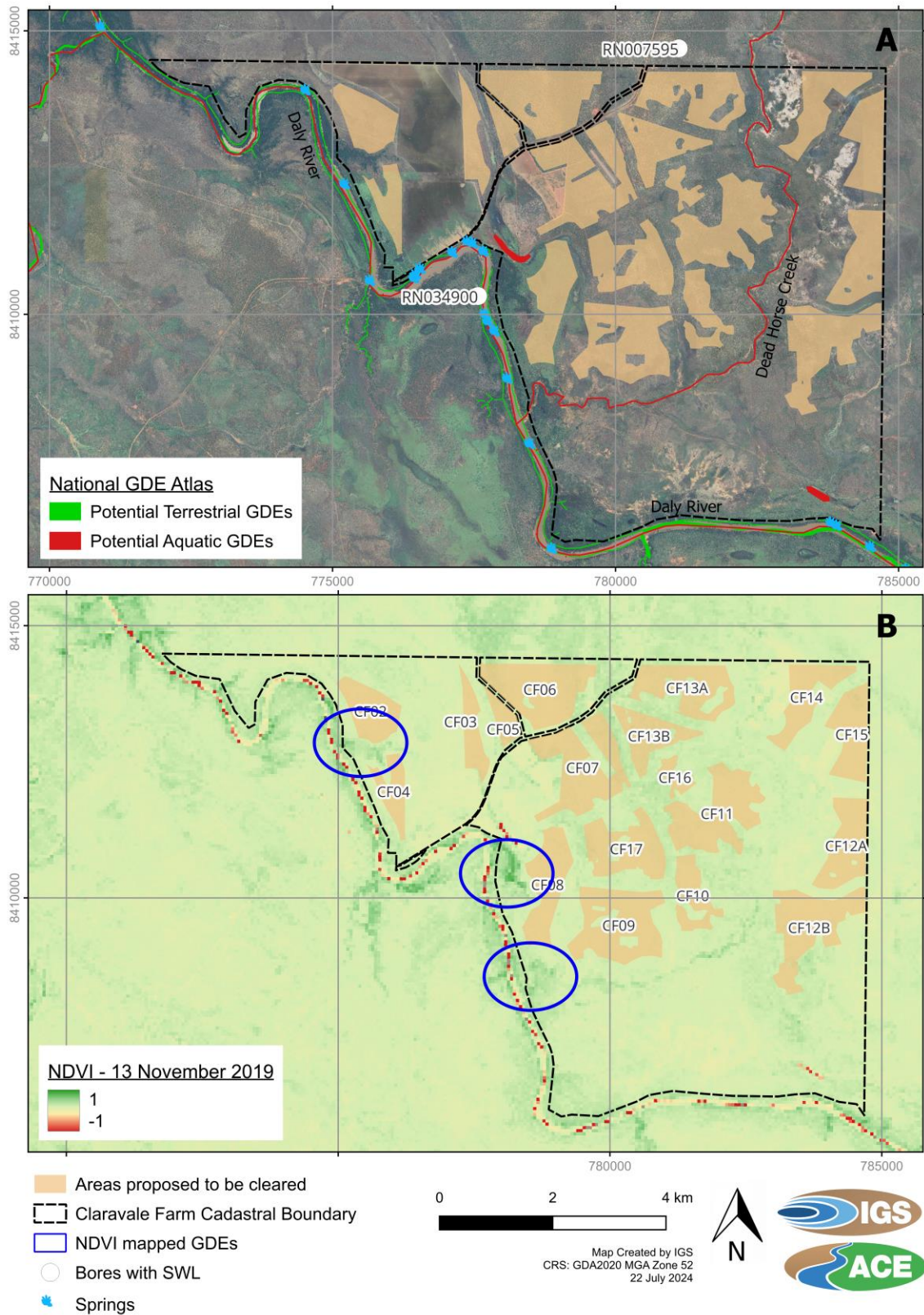


Figure 2. Claravale Farm - A) Potential GDEs mapped as per the National GDE Atlas and B) NDVI values and potential GDEs derived from Sentinel 2 imagery for the 13 November 2024.

NR Maps was used to identify sightings of threatened or significant species (flora and fauna) in the area of interest (within Claravale Farm boundary and the Daly River adjacent). Five threatened fauna species were listed, all likely to utilise aquatic and terrestrial groundwater dependent ecosystems as habitat. Ten significant fauna species and two flora species were also listed. Species are provided in **Table 1**.

Table 1. Threatened and Significant flora and fauna within Claravale farm boundaries and adjacent Daly River

Species (Scientific)	Species (Common Name)	Status
Fauna		
Varanus mertensi	Merten’s Water Monitor	Threatened
Varanus mitchelli	Mitchell’s Water Monitor	Threatened
Trachiopsis victoriana	Victoria River Squat Snail	Threatened
Rattus tunneyi	Pale Field Rat	Threatened
Carettochelys insculpta	Pig-nosed Turtle	Threatened
Merops ornatus	Rainbow Bee-eater	Significant
Crocodylus porosus	Saltwater Crocodile	Significant
Craterocephalus stercusmuscarum	Flyspecked Hardyhead	Significant
Ardea alba	Great Egret	Significant
Ardeotis australis	Australian Bustard	Significant
Pseudomys nanus	Western Chestnut Mouse	Significant
Carettochelys insculpta	Barred Grunter	Significant
Amniataba percoides	Northern Purple-spotted Gudgeon	Significant
Mogurnda mogurnda	Mulga Snake	Significant
Burhinus grallarius	Common Sandpiper	Significant
Flora		
Grevillea benthamiana	Grevillea	Significant
Nicotiana monoschizocarpa	Nicotiana	Significant

Claravale Farm sits in the Daly Basin biodiversity region. No significant conservation areas are identified within the area of interest including the Directory of Important Wetlands, Sites of Conservation Significance or Sites of Botanical significance. However, the list of identified threatened and significant species that are potentially present at GDE sites indicates a high biodiversity value.

The potential values identified above could not be verified through a field visit, but the retrieved records indicate the value of the identified GDEs should be considered to be ‘High’ according to the levels provided in the NTPS LCG. GDEs with ‘High’ values should not be cleared and be protected by a minimum buffer width of 250m of retained native vegetation.

The outer edge of the identified GDEs (National GDE Atlas and those identified from satellite imagery) were mapped using the guidance provided in the NTPS LCG, and the minimum buffer for a ‘High’ value GDE applied (**Figure 3**). This assessment indicates that three of the proposed areas to be cleared should be amended to ensure the local GDEs are protected. This includes

the southern portion of Block CF02, the northern portion of block CF04 and the eastern and southern portions of block CF08. All other blocks remain outside the buffer zones of the identified GDEs.

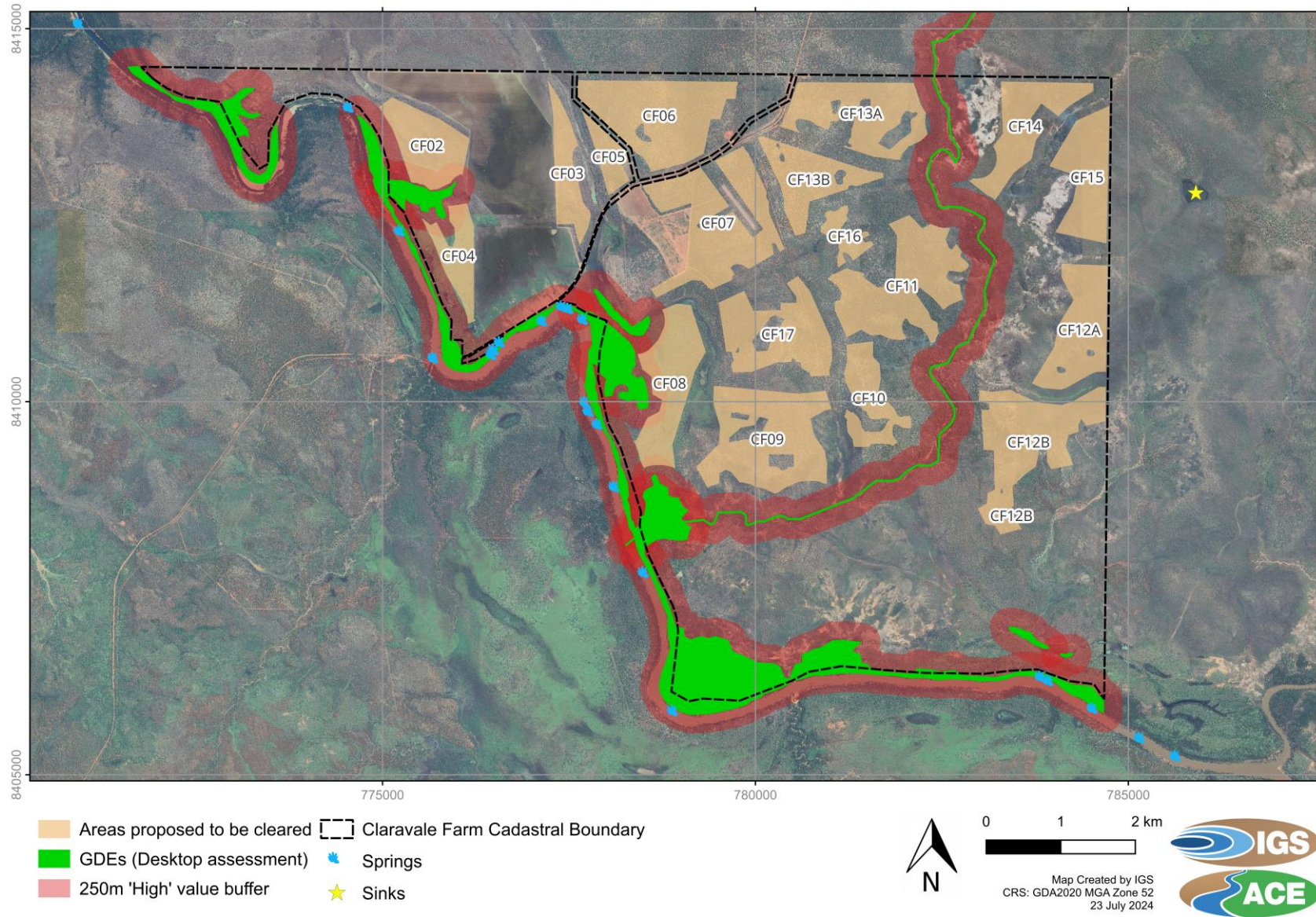


Figure 3. Claravale Farm – GDES mapped during desktop assessment and NTPS LCG 250m 'High' value buffer

NT 1169, Claravale Station

Claravale Station borders the Fergusson River to the south and although non-perennial, persistent waterholes often remain throughout the dry season in the lower reaches of the catchment (Begg et al. 2001). The width of riparian vegetation bordering the Fergusson River varies along its length, with larger areas often associated with in-channel vegetation. Polly Creek and Eight Mile Creek are also non-perennial and drain south and east from the station into the Fergusson River. Numerous sinkholes have been mapped in the mid-northern portion of the station.

Spatial layers from the GDE Atlas show potential GDEs located within and adjacent to the Claravale Station cadastral boundary (**Figure 4A**). These include both aquatic and terrestrial GDEs. The aquatic GDEs are generally associated with the main drainage lines of the Fergusson River, Eight Mile Creek and Polly Creek. The terrestrial GDEs include the riparian vegetation bordering and within the channel of the Fergusson River.

The NDVI imagery (**Figure 4B**) generally corroborates the Atlas mapping with areas of persistent green located along the length of the Fergusson River. A wetland area between the Eight Mile and Polly creeks also shows persistent productivity although it is unlikely to be a GDE but more likely due to the presence of clayey, poorly draining, soils which retain moisture through the dry season (Begg et al. 2001; DEPWS, 2008). Additionally, no springs are mapped in the wetland area. The potential aquatic GDEs associated with the creeks were not able to be verified using the NDVI imagery.

Three bores were used to assess depth to water across the station. RN008219 and RN008262 are located at the northern tip of the areas proposed to be cleared, and > 15km north west of the Fergusson River. SWL was recorded in RN00219 in 2007 and 2008 at -60.05 mbgl and -64.52 mbgl, respectively. SWL at RN008262 was similar, with eleven measurements between 2007 and 2012 ranging between -53.27 mbgl (at the end of the wet season) to -64.15 mbgl (in the dry season). RN034592 is located ~4.6km east of the station boundary and only 100m from the banks of the Edith River (a tributary of the Fergusson River). SWL was recorded thirteen times between 2005 and 2010 with levels ranging from -3.72 mbgl to -6.03 mbgl. These values may also be indicative of depth to groundwater close to the Fergusson River to the east and indicates the potential for vegetation to access this water. Depth to groundwater is likely to increase rapidly with distance from the rivers or drainage lines as the topography increase in height.

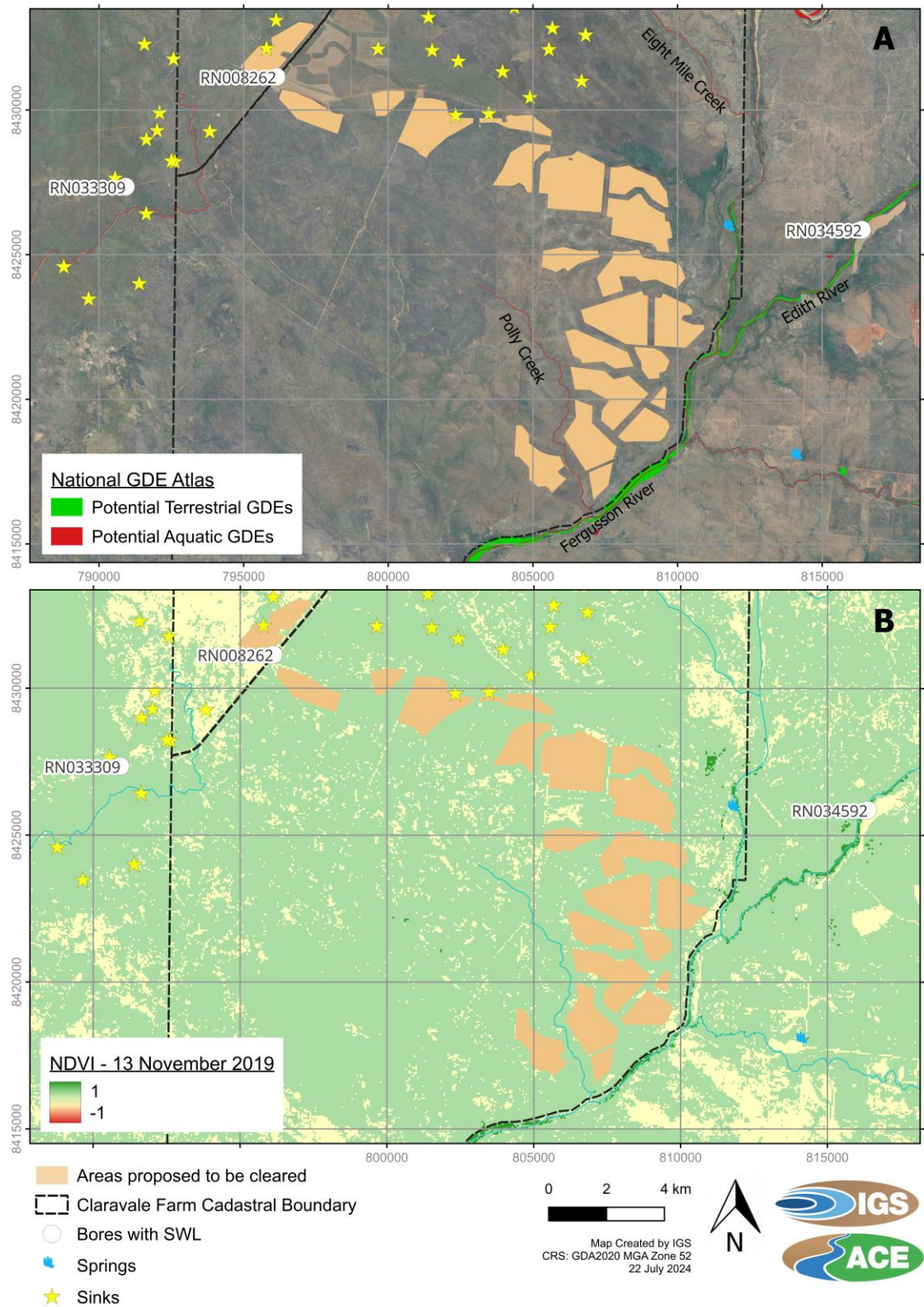


Figure 4. Claravale Station – A) Potential GDEs mapped as per the National GDE Atlas and B) NDVI values and potential GDEs derived from Sentinel 2 imagery for the 13 November 2024.

NR Maps was used to identify sightings of threatened or significant species (flora and fauna) in the area of interest (within Claravale Station boundary and the Fergusson River adjacent). Five threatened fauna species were listed, all likely to utilise aquatic and terrestrial groundwater dependent ecosystems as habitat. Fourteen significant fauna species and four flora species were also listed. Species are provided in **Table 2**.

Table 2. Threatened and Significant flora and fauna within Claravale Station boundaries and adjacent Fergusson River

Species (Scientific)	Species (Common Name)	Status
Fauna		
Macroderma gigas	Ghost Bat	Threatened
Chloebia gouldiae	Gouldian Finch	Threatened
Varanus mertensi	Mertens' Water Monitor	Threatened
Geophaps smithii smithii	Partridge Pigeon (eastern)	Threatened
Trachiopsis victoriana	Victoria River Squat Snail	Threatened
Ardea alba	Great Egret	Significant
Haliaeetus leucogaster	White-bellied Sea-Eagle	Significant
Bubulcus ibis	Cattle Egret	Significant
Merops ornatus	Rainbow Bee-eater	Significant
Rhinonictes aurantia	Orange Leaf-nosed Bat	Significant
Apus pacificus	Fork-tailed Swift	Significant
Psephotellus dissimilis	Hooded Parrot	Significant
Poecilodryas cerviniventris	Buff-sided Robin	Significant
Crocodylus porosus	Saltwater Crocodile	Significant
Lophoictinia isura	Square-tailed Kite	Significant
Burhinus grallarius	Bush Stone-curlew	Significant
Amniataba percoides	Barred Grunter	Significant
Craterocephalus stercusmuscarum	Flyspecked Hardyhead	Significant
Actitis hypoleucos	Common Sandpiper	Significant
Flora		
Grevillea benthamiana	Grevillea	Significant
Spermacoce gibba	Spermacoce	Significant
Synostemon trachyspermus		Significant
Croton dockrillii	Croton	Significant

Claravale Station sits in the Daly Basin biodiversity region. No significant conservation areas are identified within the area of interest including the Directory of Important Wetlands, Sites of Conservation Significance or Sites of Botanical significance. Yinberrie Hills, a site of Conservation Significance, is located ~2.5km to the east of the station boundary and is a key site for the nationally endangered Gouldian Finch due to its unique combination of habitat features (Harrison et al, 2009).

The potential values identified above could not be verified through a field visit, but the retrieved records indicate the value of the identified GDEs should be considered 'High' in the

absence of specific field studies. GDEs with 'High' values should not be cleared and be protected by a minimum buffer width of 250m of retained native vegetation.

The outer edge of the identified GDEs (National GDE Atlas and those identified from satellite imagery) were mapped using the guidance provided in the NTPS LCG, and the minimum buffer applied (**Figure 5**). This assessment indicates that two of the proposed areas to be cleared should be amended to ensure the local GDEs associated with Pollys Creek are protected. This includes the eastern portion of Block CS33, and the western portion of block CS330. All other blocks remain outside the buffer zones of the identified GDEs.

Minimum buffer zones were also applied for sinkholes. The majority of the areas proposed to be cleared sit outside the sinkhole buffer zones, but block CS15 appears to slightly overlap. The exact location of sinkholes should be confirmed prior to clearing to ensure these features also remain protected.

Additionally, consideration should be given to applying a buffer to the wetland / dampland adjacent to CS19, although they are unlikely to be GDEs, as they will hold similar biodiversity value. Currently blocks CS18 and CS19 encroach into this area.

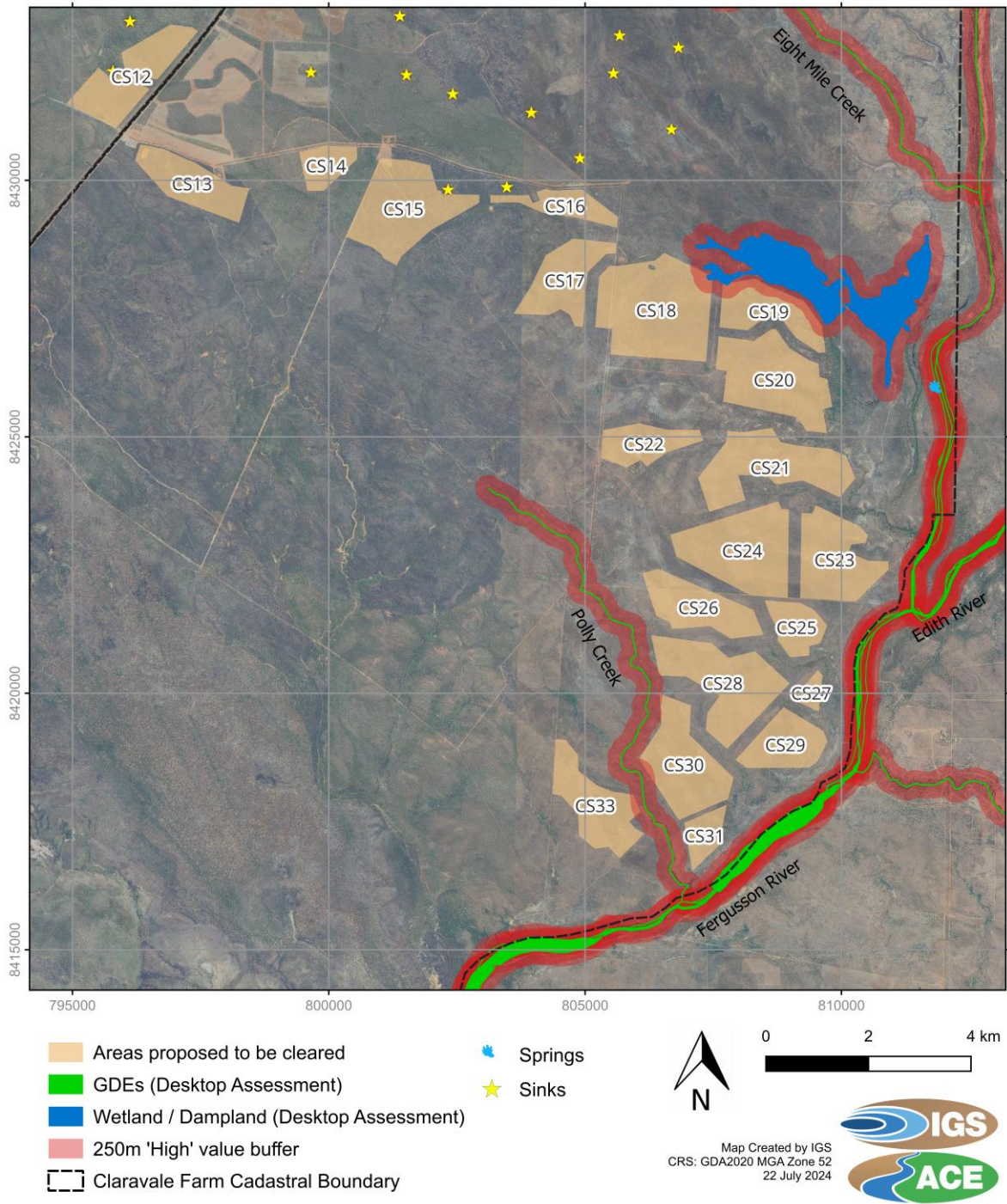


Figure 5. Claravale Station - GDES mapped during desktop assessment and NTPS LCG 250m 'High' value buffer.

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