Hoffmann Drilling Pty Ltd Superannuation Fund v Gold Coast City Council & Ors

Planning and Environment Court Appeal No137 of 2020

Joint Expert Report on climate change in relation to the proposed commercial groundwater extraction between:

- Trevor Johnson (**TJ**) of SLR Consulting retained by Hoffmann Drilling on climate change issues (Dr Johnson is also acting for Hoffmann Drilling in relation to groundwater); and
- Professor Brendan Mackey (**BM**) retained by the Australian Rainforest Conservation Society in relation to ecology and climate change.

Dr Johnson and Professor Mackey's Curricula Vitae are attached in Appendix A.

STATEMENT TO COURT

We, the undersigned, hereby acknowledge that we have been instructed on an expert's duty to assist the Court and that, that duty overrides any obligation we may have to any party to the proceedings or to any person who is liable for our fees or expenses.

We furthermore state that no instructions were given or accepted to adopt or reject any particular opinion in preparing this report.

BACKGROUND

In April 2018, Hoffmann Drilling Pty Ltd Superannuation Fund [**Hoffmann Drilling**] made application to Gold Coast City Council [**Council**] for a Material Change of Use for extractive industry (commercial groundwater extraction) on land located at 263 Repeater Station Road, Springbrook. The land is described cadastrally as Lot 36 on RP 139816.

Council refused the development application by Decision Notice dated 12 December 2019. Council's relevant reasons for refusal, inter alia, relate primarily to the development not having demonstrated that the proposed use will not impact on matters of environmental significance.

Thynne Macartney Solicitors acting on behalf of Hoffmann subsequently lodged a Notice of Appeal (No 137 of 2020) with the Planning & Environment Court on 17 January 2020.

The Australian Rainforest Conservation Society [**ARCS**] was a submitter to the application and has subsequently joined the appeal as a Co-Respondent by Election. ARCS has elected to call evidence in respect of climate change and its impacts, and has nominated BM to provide that evidence. Hoffmann Drilling has subsequently engaged TJ to contribute to the JER process.

The experts have been provided with the joint expert report on groundwater, dated 23 October 2020, prepared by TJ, Tony McAlister and Dr Matthew Currell, along with the background material contained therein.

BM also has reviewed the following report prepared for the Appellant in relation to a previous development application: Planit Consulting, *Flora and Fauna Assessment – Lot 36 RP139816 @ 263 Repeater Station Road, Springbrook – Prepared for Graeme Hoffman*, April 2015. This report was prepared in 2015 by a local flora and fauna expert, Graham Dart, and other consultants for the Appellant for an earlier development application for a dwelling house on the western boundary of the land the subject of this appeal.

TJ notes that this JER is intended to deal solely with climate change. He has therefore removed any comments made by BM relating to ecology in the Points of Agreement below since TJ is not an ecologist.

BM notes that this JER is focussed on climate change and its impacts and therefore must include consideration of current or projected ecological impacts.

POINTS OF AGREEMENT

1. It is relevant to consider climate change impacts on the area's groundwater, and cascading impacts effects for flora and fauna, because the proposed commercial groundwater extraction may impact on the natural hydro-ecological relations between the native forest ecosystems and the groundwater resource.
2. The groundwater resources of the Springbrook Plateau are essential to the long-term resilience and health of the native forest ecosystems and constituent species. These groundwater resources sustain plant growth and are especially important in droughts for sustaining photosynthesis and other essential ecological processes that need a constant supply of water. The groundwater/aquifer, therefore, is an abiotic component of the rainforest ecosystem. Groundwater levels are impacted by climatic controls on rainfall and their water's extraction for human use.
3. Australia, south east Queensland and the Springbrook Plateau are characterized by seasonal rainfall and high variability in year-to-year rainfall, especially in winter (Figure 12) and severe droughts (Figure 13). Furthermore, a long-term drying trend is now evident based on the observed rainfall records (Figure 14).

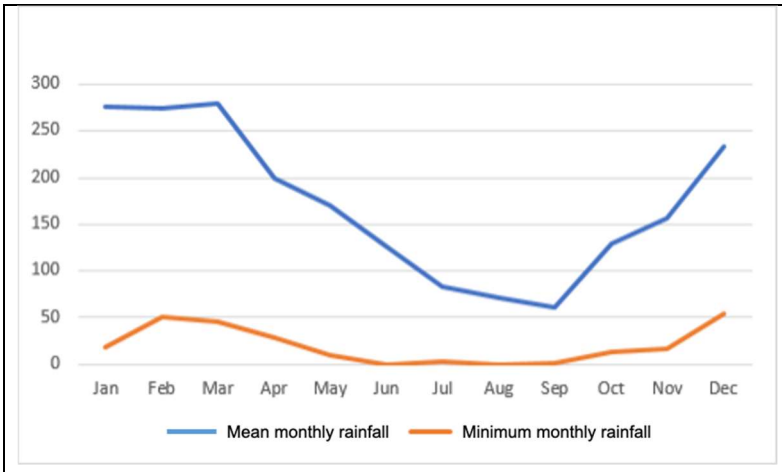


Figure 12 Mean and monthly rainfall for Springbrook Road, 1981-2020. Bureau of Meteorology. Climate Change Data Online. Note minimum recorded minimums in the winter months.

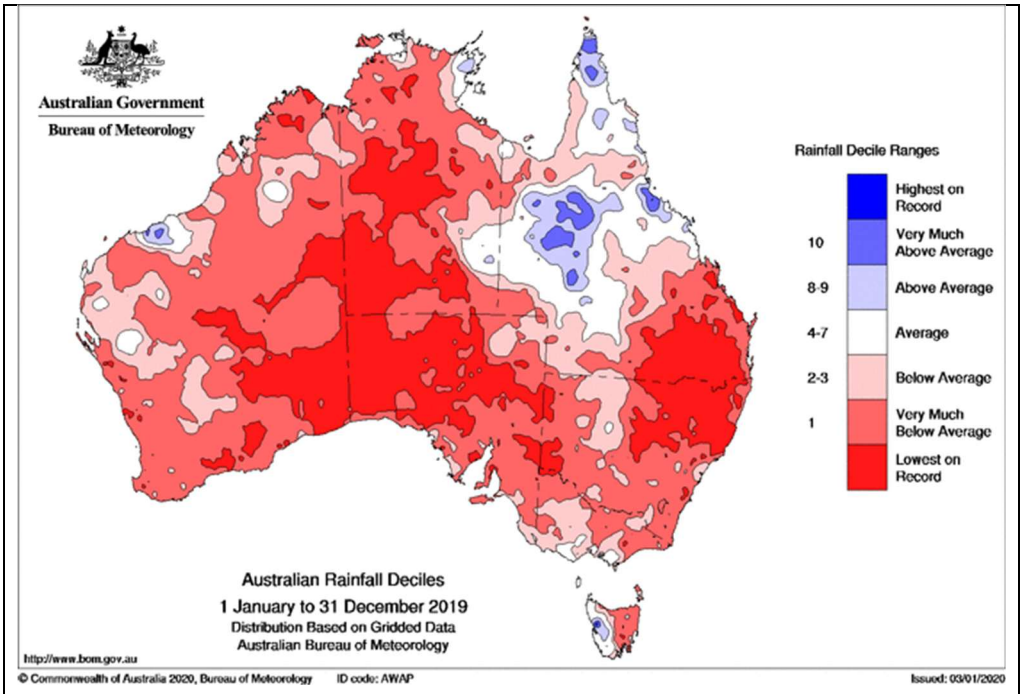


Figure 13 Australian rainfall for 2019. Note SEQ had lowest on record

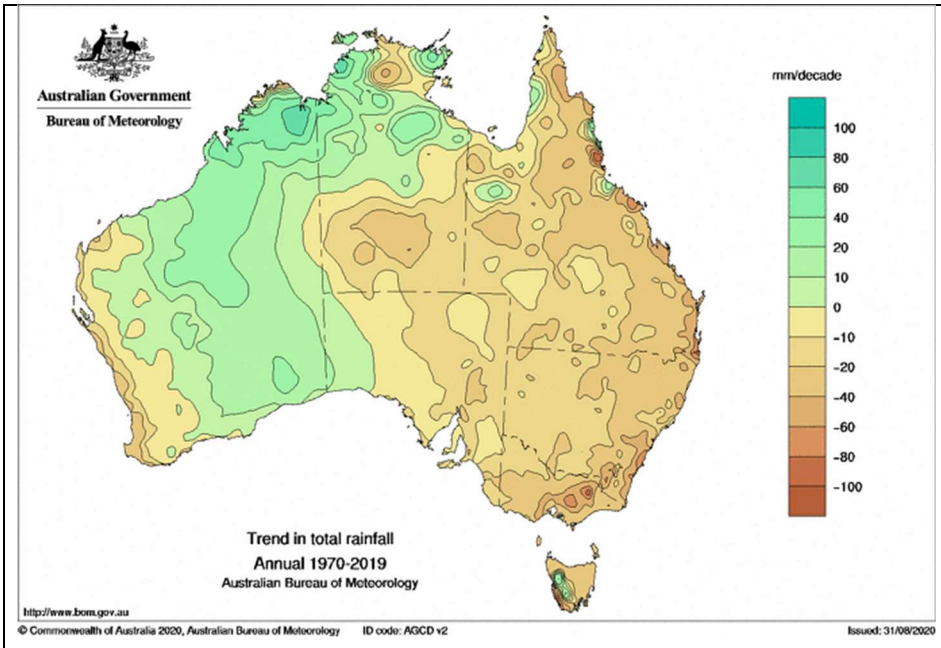
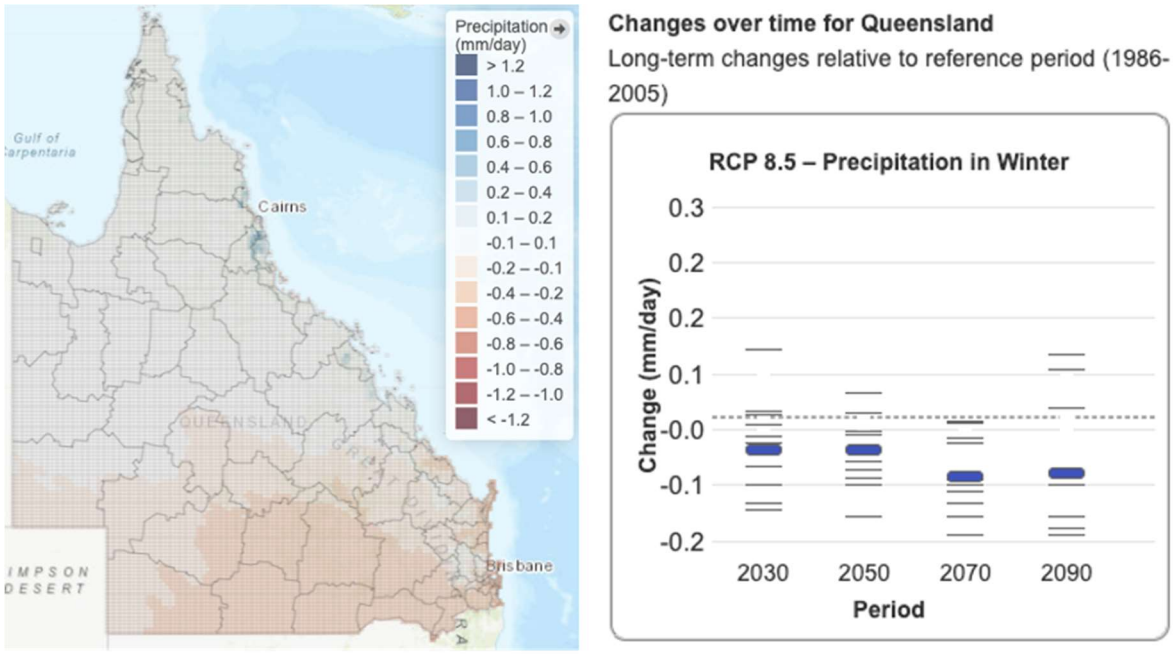


Figure 14 Last 50 -years trend in annual rainfall. Note SEQ has major declining trend (minus 20 to minus 60%)



Source: Queensland Future Climate Dashboard, Queensland Government
https://www.longpaddock.qld.gov.au/qld-future-climate/dashboard/

Figure 15. Projected decrease in winter rainfall from climate change, assuming global greenhouse gas emissions continue unabated.

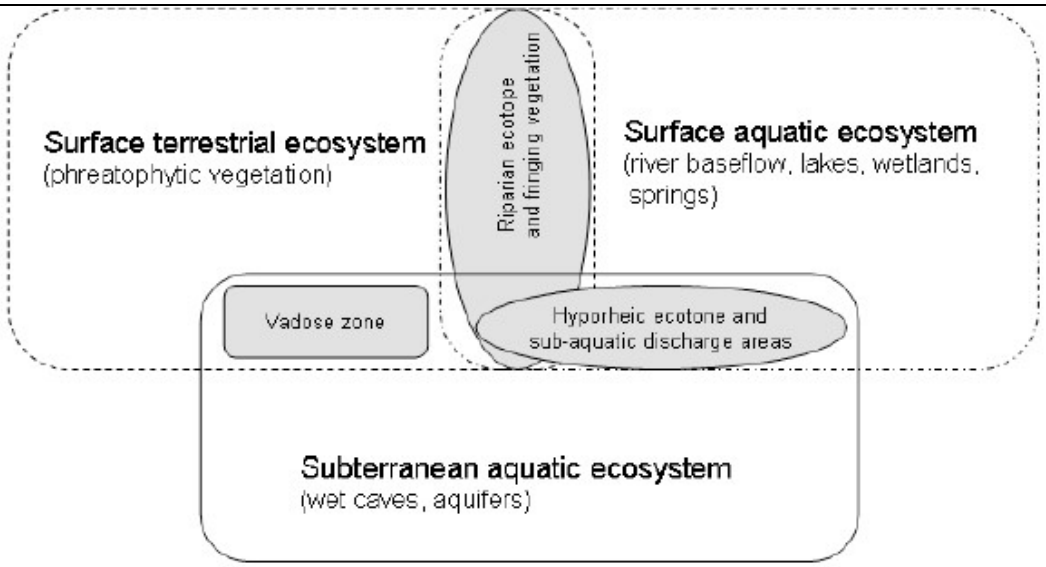


Figure 16. The different types of ground water dependent ecosystems in Australia. The native forests of Springbrook Plateau are examples of phreatophytic ground water dependent ecosystems.

POINTS OF DISAGREEMENT

4. BM wishes to include the following information in respect of the definition of environmental significance. All of the information in the following paragraphs up to the next paragraph commencing "TJ says" is attributed to BM

5. BM understands that broadly speaking, the assessment benchmarks in City Plan relevant to assessing the proposed development require any "matters of environmental significance" to be protected, including for buffer areas and connectivity of fauna habitat. The many provisions in City Plan reflecting this broad requirement in a variety of ways are set out in the Respondent's List of Matters as reasons for refusal, filed on 23 July 2020, which I have been provided with.

6. "Matters of environmental significance" are defined in Table SC1.2.2 (Administrative definitions) of City Plan by cross-reference to the *State Planning Policy* (July 2017) as follows:

Matter of environmental significance	The collective term referring to any environmental matter that is either a matter of national environmental significance, matter of state environmental significance or matter of local environmental significance.
Matter of local environmental significance	As defined in the *State Planning Policy*.
Matter of national environmental significance	As defined in the *State Planning Policy*.
Matter of state environmental significance	As defined in the *State Planning Policy*.

7. Part F (Glossary) of the *State Planning Policy* (July 2017) defines "matters of environmental significance", and related terms of matters of local, state and national significance, as follows (highlighting of matters particularly relevant to the present appeal):

> **Matters of environmental significance** means any of the following:
>
> (a) matters of local environmental significance
>
> (b) matters of state environmental significance
>
> (c) matters of national environmental significance.
>
> **Matters of local environmental significance (MLES)** means natural values and/or areas identified by a local government in a planning instrument as MLES that are not the same, or substantially the same, as matters of national environmental significance or matters of state environmental significance.
>
> Note: A regional plan may identify natural values or areas for investigation and refinement by local government for protection as MLES.
>
> **Matters of national environmental significance (MNES)** means the following matters protected under the *Environment Protection and Biodiversity Conservation Act 1999*, chapter 2, part 3:
>
> - world heritage properties
> - national heritage places
> - wetlands of international importance
> - listed threatened species and communities
> - listed migratory species
> - Commonwealth marine areas
> - the Great Barrier Reef Marine Park.
>
> Note: MNES listed above contain natural values, features and areas that are to be considered in applying the biodiversity state interest of the SPP.

World heritage properties and natural heritage places may also be listed for cultural heritage significance. In these instances, world heritage properties and national heritage places are also to be considered as part of the cultural heritage state interest.

Matters of state environmental significance (MSES) means the following natural values and areas:

(a) protected areas (including all classes of protected area except coordinated conservation areas) under the *Nature Conservation Act 1992*

(b) 'marine national park', 'conservation park', 'scientific research', 'preservation' or 'buffer' zones under the *Marine Parks Act 2004*

(c) areas within declared fish habitat areas that are management A areas or management B areas under the Fisheries Regulation 2008

(d) a designated precinct, in a strategic environmental area under the Regional Planning Interests Regulation 2014, schedule 2, part 5, s15(3)

(e) wetlands in a wetland protection area or wetlands of high ecological significance shown on the map of referable wetlands under the Environmental Protection Regulation 2008

(f) wetlands and watercourses in high ecological value waters identified in the Environmental Protection (Water) Policy 2009, schedule 1

(g) legally secured offset areas as defined under the *Environmental Offsets Act 2014*.

(h) threatened wildlife under the *Nature Conservation Act 1992* and special least concern animals under the Nature Conservation (Wildlife) Regulation 2006

(i) marine plants under the *Fisheries Act 1994* (excluding marine plants in an urban area)

(j) waterways that provide for fish passage under the *Fisheries Act 1994* (excluding waterways providing for fish passage in an urban area)

(k) high risk area on the flora survey trigger map as described in the Environmental Offsets Regulation 2014, schedule 2, part 6(1)

(l) regulated vegetation under the *Vegetation Management Act 1999* that is:

  (i) category B areas on the regulated vegetation management map, that are 'endangered' and 'of concern' regional ecosystems

  (ii) category C areas on the regulated vegetation management map that are 'endangered' and 'of concern' regional ecosystems

  (iii) category R areas on the regulated vegetation management map

  (iv) areas of essential habitat on the essential habitat map for wildlife prescribed as 'endangered wildlife' or 'vulnerable wildlife' under the *Nature Conservation Act 1992*

  (v) category A, B, C or R areas on the regulated vegetation management map that are located within a defined distance

from the defining banks of a relevant watercourse identified on the vegetation management watercourse and drainage feature map

(vi) category A, B, C or R areas on the regulated vegetation management map that are located within a wetland or within 100 metres from the defining bank of a wetland identified on the vegetation management wetlands map.

Note: Where possible, MSES is indicatively shown on the SPP IMS

8. In broad summary, therefore, I understand that in this appeal I am asked to assist the Court to assess the impacts of the proposed development against the assessment benchmarks identified in the City Plan that protect "matters of environmental significance", which relevantly include:

    1. World Heritage properties, including the Gondwana Rainforests of Australia World Heritage Area of which Springbrook is a part (see Figure 1);

    2. listed threatened species protected under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (**EPBC Act**) both on and off the site;

    3. protected areas under the *Nature Conservation Act 1992* (Qld) (see Figure 1);

    4. threatened wildlife and special least concern animals under the *Nature Conservation Act 1992* (Qld) both on and off the site;

    5. high risk area on the flora survey trigger map as described in the *Environmental Offsets Regulation 2014*, schedule 2, part 6(1), both on and off the site;

    6. areas of essential habitat on the essential habitat map for wildlife prescribed as "endangered wildlife" or "vulnerable wildlife" under the *Nature Conservation Act 1992* (Qld) both on and off the site; and

    7. native species of flora and fauna and their habitat on and around the site (including species such as the Pouched Frog (*Assa darlingtoni*) identified in the dependent on moist soil for breeding known to occur on the property).

9. As in GTH *Resorts No 5 Pty Ltd v Gold Coast City Council* [2020] QPEC 20 (Williamson QC DCJ), at [103]-[104], the "land's strategic location in an ecological sense" for connectivity of habitat is relevant to consider as is the buffer and resilience it provides for surrounding areas of ecological importance.

10. In considering the impacts of the development on these matters of environmental significance, as agreed in the Groundwater Joint Expert Report dated 23 October 2020 at point 10 of the points of agreement, the groundwater on the site flows to the Boy-Ull Creek, which flows over the edge of the Springbrook plateau at Twin Falls in Springbrook National Park, part of Gondwana Rainforests of Australia World Heritage Area, and to Cave Creek to the west (Figure 1).

11. Virtually the whole of the site is mapped as a high risk area on the flora survey trigger map and areas of essential habitat for wildlife (see **Error! Reference source not found.**, **Error! Reference source not found.** and Appendix 2).

12. I understand that means that the Court must consider the impacts of the proposed development on fauna and flora both on the site and off the site and the surrounding World Heritage areas and national parks. I have approached this joint expert report in this context.

13. Furthermore, in reporting on **climate change** in relation to the proposed commercial groundwater extraction I have followed the impact assessment framework of the International Panel on Climate Change (IPCC) Working Group II – Impacts, Vulnerability and Adaptation. This is the world standard for climate change impact assessment endorsed by the Australian Government. The IPCC approach requires that climate-related impacts are assessed in terms of how they affect the values and objectives of all relevant systems and assets. Here, this requires assessing the impacts of current and projected climate change in relation to the above listed matters of environmental significance, including the impacts off site and in the surrounding World Heritage areas and national parks. Of particular interest therefore, is how climate change impacts the Springbrook landscape systems and associated natural assets. I have therefore focussed on the following critical components and their interactions:

    I. ***Climate change and groundwater dependent ecosystems*** – because of the strong connections between climate, the native forests of the World Heritage Areas and national parks, rainfall and groundwater;
    II. ***Climate change and fire risk*** – because of the strong connections between climate, fire weather conditions, fire risk and forest fires; and
    III. ***Climate change and cascading risk to flora and fauna*** – because of the strong connections between climate, native forests and wildlife habitat.

Figure 1: Proposed bore sites at 263 Repeater Station Road and nearby existing commercial groundwater extraction sites and surrounding national park and World Heritage Areas, including Twin Falls (Source: ARCS)

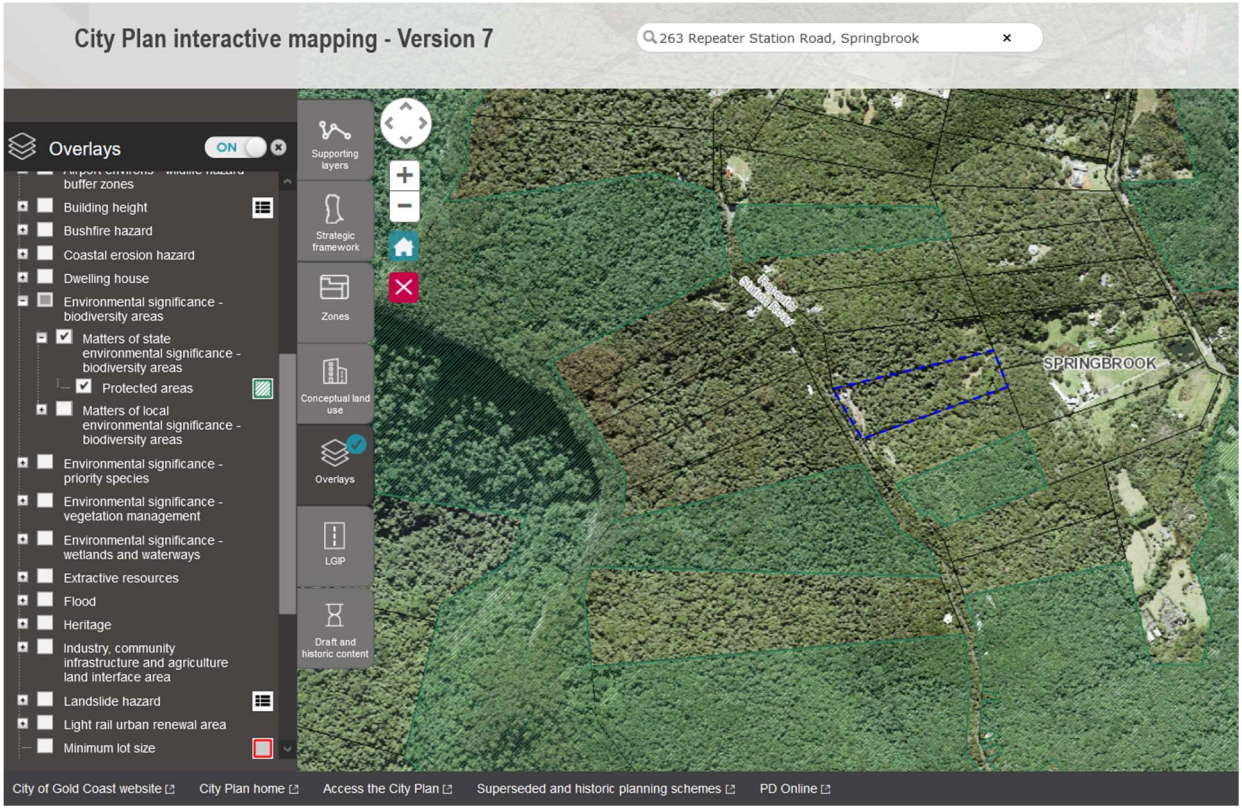


Figure 2: Extract from City Plan interactive maps showing nearby protected areas around the land mapped in the Environmental Significance – Biodiversity Areas overlay

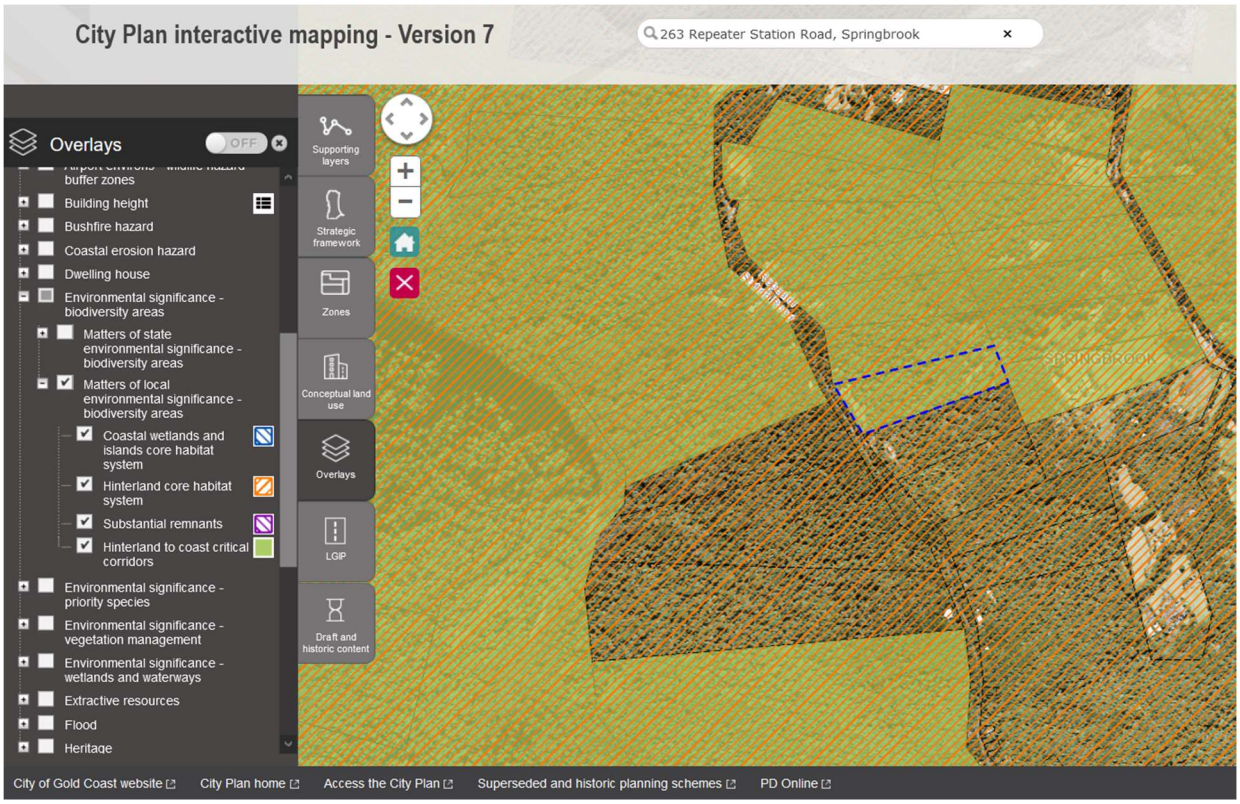


Figure 3: Extract from City Plan interactive maps showing the land is included in the Hinterland Core Habitat System and the Hinterland to Coast Critical Corridors mapped in the Environmental Significance – Biodiversity Areas overlay under the Environmental Significance Overlay Code

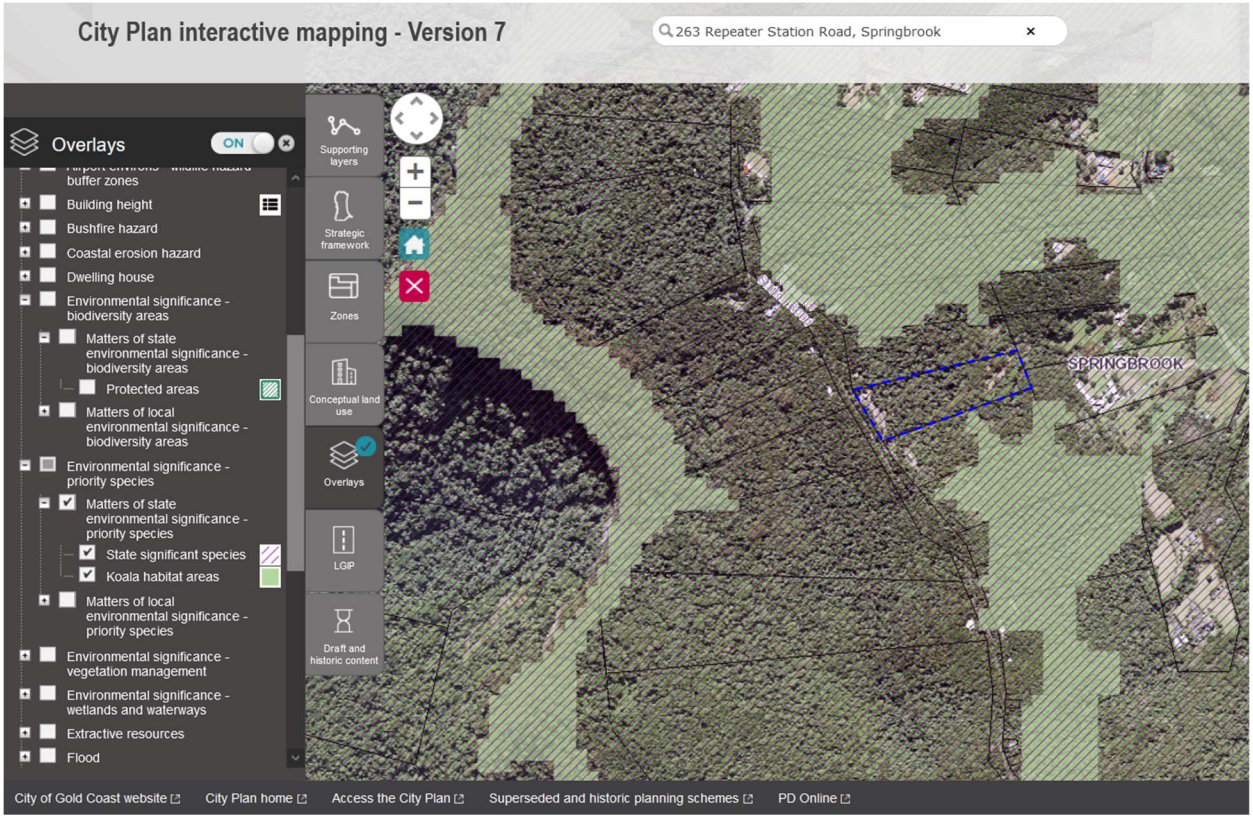


Figure 4: Extract from City Plan interactive mapping showing the land is mapped as a matter of state environmental significance – priority species overlays for State significant species (with koala habitat areas nearby)

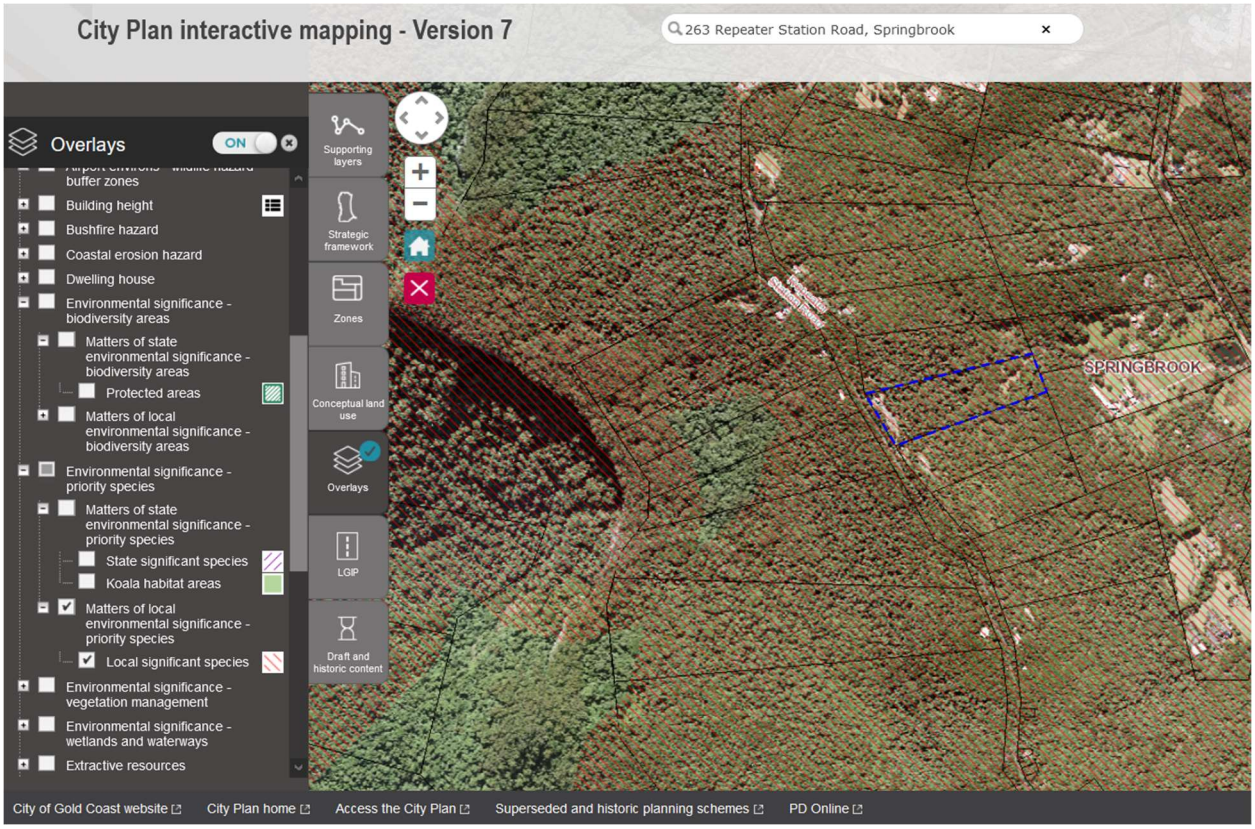


Figure 5: Extract from City Plan interactive mapping showing the land is mapped as a matter of state environmental significance – priority species overlays for local significant species

Figure 6: Extract from City Plan interactive mapping showing the land is mapped within the matters of local environmental significance – vegetation management overlay and identified in the vegetation management – General Priority vegetation overlay

Figure 7: Extract from Queensland Globe showing virtually all of the land is identified as a high risk area on a protected plants flora survey trigger map under the *Nature Conservation Act 1992* (Qld).

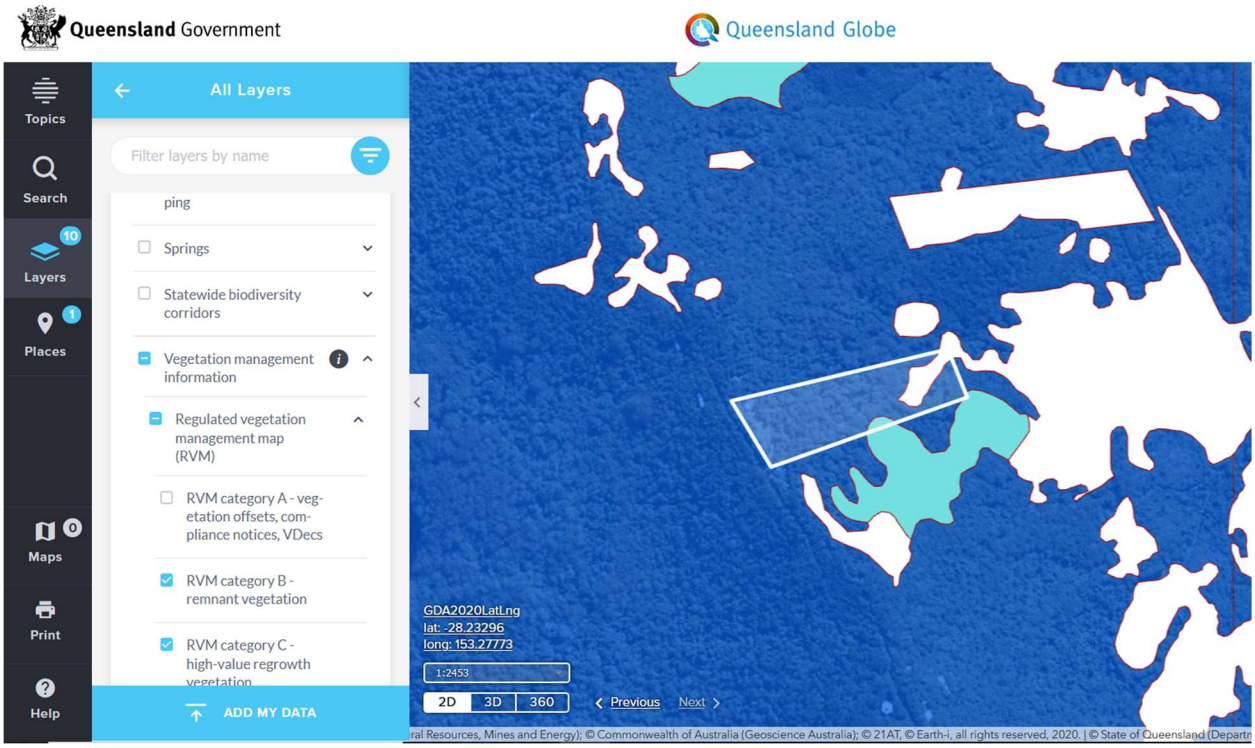


Figure 8: Extract from Queensland Globe showing most of the site is identified as RVM category B – remnant vegetation (dark blue). A small patch on the southern boundary is identified as RVM category C – high value regrowth vegetation (light blue).

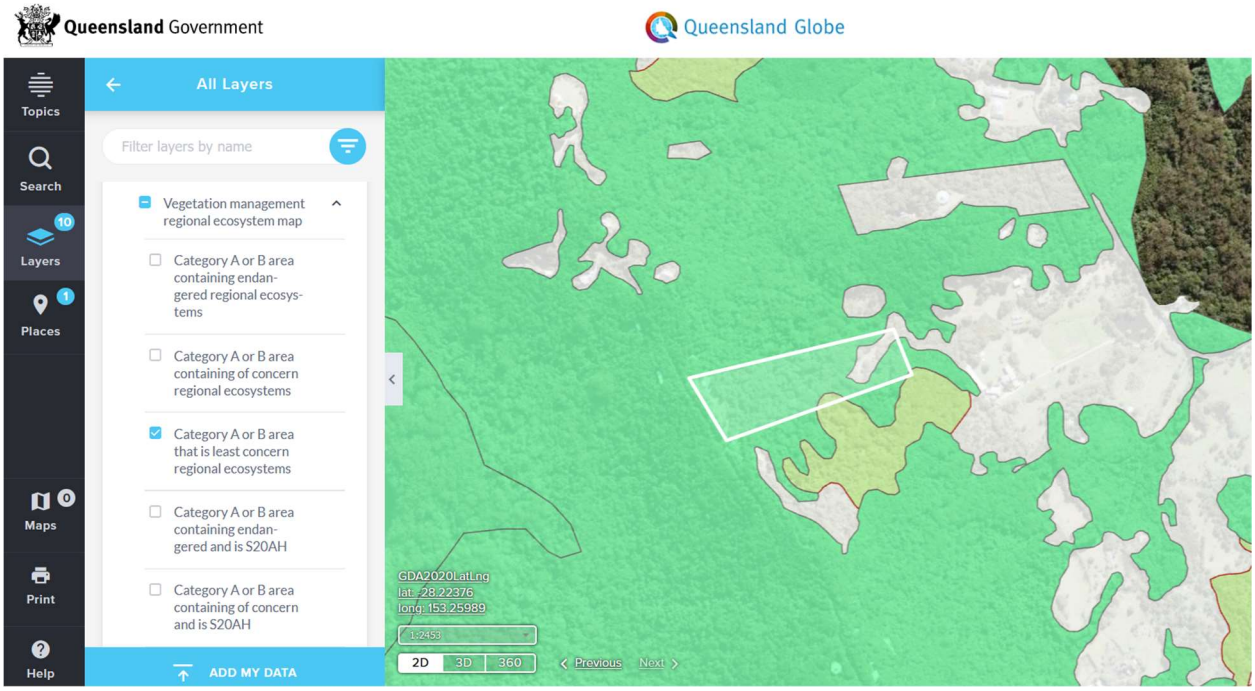


Figure 9: Extract from Queensland Globe showing most of the vegetation on the site is identified as Category A or B area that is least concern regional ecosystems under the *Vegetation Management Act 1999* (light green)

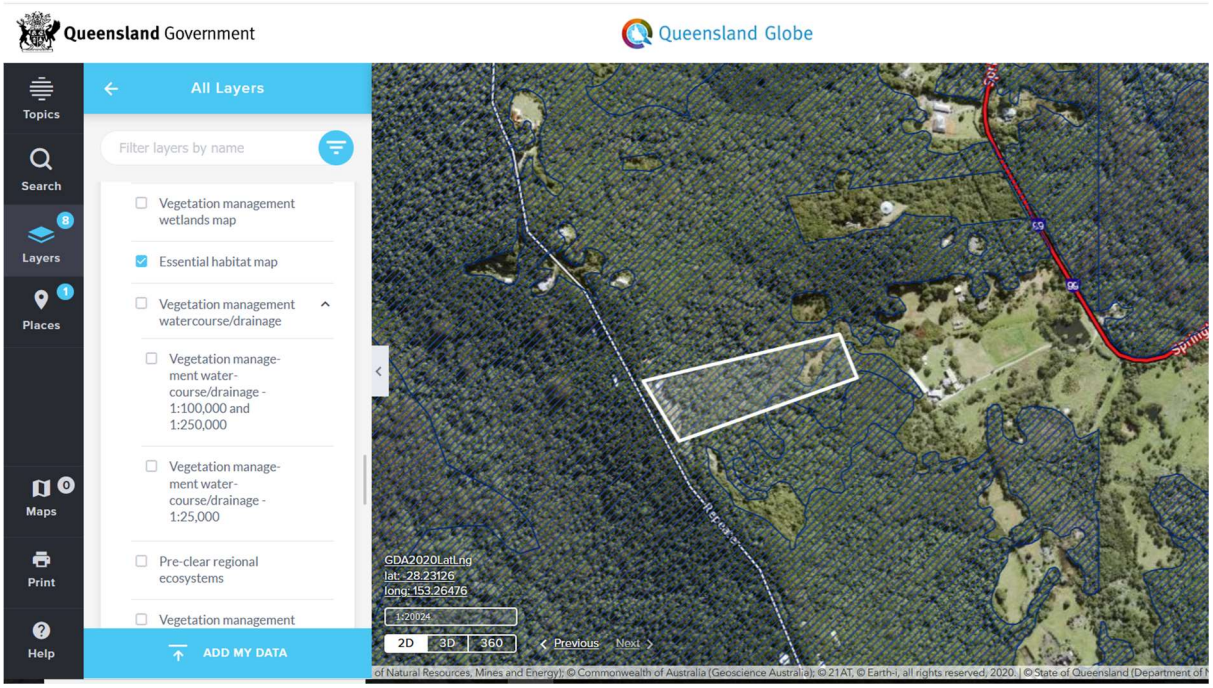


Figure 10: Extract from Queensland Globe showing that most of the site is identified as "essential habitat" under the *Nature Conservation Act 1992* (Qld)

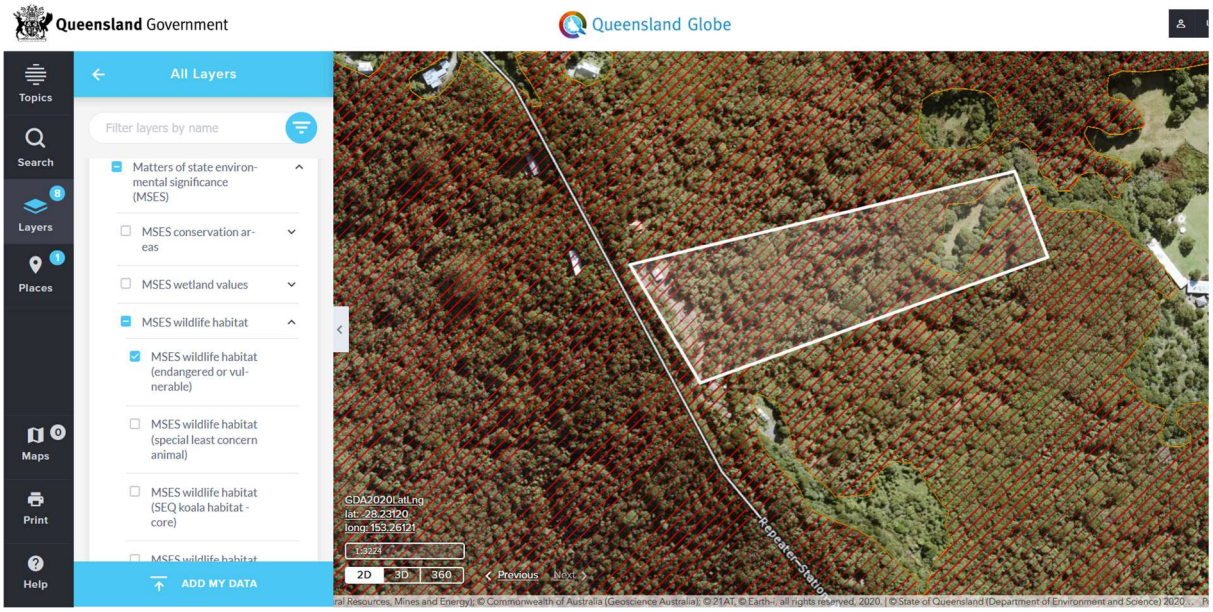


Figure 11: Extract from Queensland Glove showing most of the site is identified as MSES wildlife habitat (endangered or vulnerable)

14. TJ says that he does not consider the information that BM has included in paragraphs 5 to 14 above to be particularly relevant to the matter under consideration, which is the potential effect of climate change on the operation and environmental impact of the proposed groundwater extraction. He notes that references to the State Planning Policy are not helpful, since Section 2.1 of Council's Planning Scheme contains a statement noting that the requirements of the SPP are already integrated into the Planning Scheme. Consequently, the SPP has no statutory application in respect of this matter. The relevant document is the Planning Scheme itself.

15. TJ expects that any approval of this application will involve the imposition of suitable conditions on the extraction operation, which will include likely restrictions on the extent of water table level reduction which is permitted. If climate change results in a reduction in annual rainfall totals, then this will reflect in lower water table levels, which will limit the amount of extraction which is permitted. If the impacts of climate change predicted by BM occur by the year 2100, then I would expect the conditions of approval to prevent groundwater extraction for commercial purposes. However, this is a matter for future determination and monitoring.

16. BM says that climate change will also increase fire risk and this is a relevant consideration for this development application. A related factor is that by maintaining access to groundwater during the dry season, the Springbrook vegetation is able to stay greener and moister, thereby reducing the risk of fire. This is because it is the dryness of fuel not the amount of fuel that controls fire risk1. There has been an increase in dangerous fire weather since the 1970's due to climate change and projections point to this trend continuing as a consequence of declining reliability in winter rain and dramatically increasing spring temperatures 2. It follows that maintaining the hydro-ecological connections between the groundwater and phreatophytic vegetation also reduces fire risk during extreme fire weather conditions, for example, the wildfires of 2019-2020 following a deep winter drought and early, hot spring. These are the preconditions for extreme and catastrophic wildfires, which are projected to increase in the coming decades making conventional approaches to fire risk management less effective, as noted by the report of the 2020 Royal Commissions into Royal Commission into National Natural Disaster Arrangements3. Note also that the unprecedented 2019-2020 bushfires burnt some 2,114 ha of rainforest in the neighbouring Lamington National Park, illustrating how significantly dangerous fire weather has increased.

17. BM says that the proposed commercial groundwater extraction could therefore increase the flammability of the forest in the surrounding World Heritage areas and national parks during times of dangerous fire weather by increasing the dryness of the forest vegetation as the consequence of reduced ecosystem access to water resources. The extent of these impacts caused by the development depends on the extent of the impacts it causes to groundwater both on the site and in the surrounding area (which is a matter for the groundwater experts) and the future extent of climate change (which is expected to increase over time subject to the level of global mitigation action).

18. TJ does not agree that fire risk is relevant to this application. In any case, this appears to be either an ecological or bushfire issue, neither of which TJ is qualified to address. BM's contentions should be addressed to the ecological experts as part of the conclave for that component.

19. BM states that the native forest and other vegetation ecosystems of Springbrook Plateau are all, to significant extents, groundwater dependent. In addition to surface aquatic ecosystems such as wetlands, the rainforest and wet sclerophyll forest communities of Springbrook Plateau are

[1] Ruthrof K. X. (2016) How drought-induced forest die-off alters microclimate and increases fuel loadings and fire potentials. *International Journal of Wildland Fire*, 25.

[2] Dowdy A. J. 2018. Climatological Variability of Fire Weather in Australia. Journal of Applied Meteorology and Climatology, 57, 221-234; Dowdy A. J. et al. (2019) Future changes in extreme weather and pyroconvection risk factors for Australian wildfires. *Sci Rep, 9*, 10073.

[3] The report is available at https://naturaldisaster.royalcommission.gov.au/

"phreatophytic ground water dependent ecosystems"[4]. Phreatophytic ecosystems require constant water supply to support the high level of photosynthesis needed to grow and maintain their dense green foliage and canopies[5]. In the soil, subsoil, or permeable material immediately above the water table (the vadose zone) moisture moves upwards through the hydraulic lift created by capillary action. This water is utilized by plants, provided their roots can reach this zone. The critical issue for phreatophytic vegetation such as found on the Springbrook Plateau is the depth of the water table (and its associated vadose zone) below the ground surface, and its accessibility by roots (Figure 16). The vadose zone in turn is connected to the groundwater. If abstraction lowers the water table beyond the depth from the vadose zone is recharged and at which roots can obtain water, those elements of the vegetation community with full dependence on groundwater will die. During wet seasons, plants extract most water from shallow layers where the root density is the highest. As the soil dries progressively, more water is extracted from deeper layers to keep leaf stomata open. Access to groundwater during the dry season and droughts therefore buffers the native forest from suffering plant water deficit and is a key factor in their natural resilience.

20. BM says that it follows that the proposed commercial groundwater extraction could reduce the availability of water resources to the native forest below critical levels during times of drought and/or fire weather conditions which would present a major threat to forest ecosystem health with potentially catastrophic consequences. Climate change is driving further winter drought and extreme heatwave conditions. Therefore, the proposed commercial groundwater extraction would also be generating further human caused pressures on the native forest and other vegetation, and associated fauna and flora, both on the site and off the site and the surrounding World Heritage areas and national parks at a time when all evidence points to the region experiencing increasingly more water-stress conditions. The extent of these impacts caused by the development depends on the extent of the impacts it causes to groundwater both on the site and in the surrounding area (which is a matter for the groundwater experts) and the future extent of climate change (which is expected to increase over time subject to the level of global mitigation action).

21. BM says that native vegetation provides, directly or indirectly, most of the habitat resources needed by wildlife species, including for food, shelter and reproduction. Furthermore, native vegetation, especially forest vegetation, generates and maintains the micro-environmental conditions essential for forest-dependent species. The closed canopies of the notophyll vine forest typical of Springbrook Plateau, for example, maintain cooler and moister conditions compared to cleared land. This means that the ecological-hydrological connections between the groundwater and plant growth have important cascading impacts for the native forest-dependent fauna.

22. BM believes that the proposed commercial groundwater extraction during times of drought and dangerous fire weather conditions could reduce ecosystem productivity in the surrounding World Heritage areas and national parks, resulting in degraded habitat resources for the dependent fauna, declining wildlife population numbers, and under extreme and catastrophic drought or fire conditions, species extirpations. The extent of these impacts caused by the development depends on the extent of the impacts it causes to groundwater both on the site and in the surrounding area (which is a matter for the groundwater experts) and the future extent of climate change (which is expected to increase over time subject to the level of global mitigation action).

23. Alberts Lyrebird, for example, listed as near threatened under the Nature Conservation Act 1992, is dependent on the wet, productive forest environments only found under the closed canopies, dense understoreys and deep litter layer of these forests.

24. Another example is provided by two frog species - Assa darlingtoni, Pouched Frog and Kyarranus loveridgei, Masked Mountain Frog - occurring at Upper Springbrook that breed in moist

[4] Neville J.C. et al. (2010) Groundwater-dependent ecosystems and the dangers of groundwater overdraft: a review and an Australian perspective. *Pacific Conservation Biology* 16: 187–208.
[5] Specht R.L. and Morgan D.G. (1981). The balance between the foliage projective covers of overstorey and understorey strata in Australian vegetation. Australian Journal of Ecology 6: 193-202.

soil and which do not use streams or pools for breeding. For species such as these, the critical period is during periods of drought. If forest productivity and moisture levels are not maintained during these stress periods, their long-term survival is endangered. A drop in the groundwater level during severe drought periods can therefore reduce forest ecosystem productivity with cascading impacts for the forest micro-environmental conditions and the specialised habitat requirements of the dependent fauna species.

25. TJ says that a significant component of the issues raised by BM in paragraphs 20 to 25 above relate to ecological issues. He does not suggest that the information provided by BM is incorrect, since he simply does not know whether this is the case. TJ notes that the topic of this conclave is climate change, not ecology. He is not an ecologist and is not qualified to comment on these matters. TJ says that if BM wishes to have these matters considered, it should be at the forum of the expert ecologists.

26. However, TJ will make one comment in respect of BM's assertion that all vegetation on the Springbrook plateau is groundwater dependent. TJ has had significant experience in dealing with actual Groundwater Dependent Ecosystems (GDEs), and how these may be affected by changes in the split between surface runoff and groundwater seepage as a consequence of urbanisation. In his experience, all GDEs are fed from a true groundwater resource, and not from soil moisture. The level of the water table at which groundwater is intended to be extracted (and is currently being extracted) from the Springbrook aquifer is about 830 m AHD. In comparison, the ground level at the top of the relevant bore is over 900 m AHD. It would seem apparent that the majority of vegetation above a level of 830 m AHD is not drawing water from the aquifer. Rather this vegetation is using soil water storage in the vadose zone, which is the area of soil water content between the surface and the true water table level. Substantial water resources may exist in this zone, but they are not groundwater. GDEs do certainly exist on this site, but they are located at and around the 830 m AHD contour where the water table actually breaks the ground surface. I expect that the issue of GDEs will be considered in the ecology conclave.

27. BM says that, given that the impacts of the development on groundwater are uncertain, and that the future extent of climate change regarding precipitation are currently limited, and the significant environmental values at stake, decisions should be guided by the precautionary principle whereby a lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation or mitigating risks.

28. TJ says that the issue of any impact which may arise in the future as a consequence of climate change can be satisfactorily addressed by the imposition of suitable conditions to any approval which may be granted for the development. On the basis that changes in groundwater level or vegetation can be determined by regular monitoring, TJ does not consider that there is any significant risk associated with approval of the proposed development. The reality is that climate change is occurring, and humans will need to adapt to it since any remedial measures adopted by industry are certain to take decades to centuries to reflect in modified climatic conditions. Hence, it is neither reasonable nor possible to simply avoid making decisions on the basis of uncertainty.

29. BM says that the best <u>available</u> climate projections point to a continuation in south east Queensland of the current observed drying trend (Figure 15). It is critical to note that these projections are not derived from global scale climate model as stated in the Joint Expert Report on groundwater (TJ). Rather, they are the outputs of "dynamically downscaled" regional climate models which take into account finer resolution features of Queensland's geography such as the topographic-related effects of coastal ranges. They are built upon the same physical process understanding that underpins current weather forecasts and they are able to replicate past and current climatic conditions in Australia and south east Queensland. The main factor influencing the accuracy concerns the course of greenhouse gas emissions and the international community's success or failure to mitigate greenhouse gas emissions. The projections (climate science does not use the term "predictions") shown in Figure 15 assume current levels of emissions continue unabated. However, even if

emissions reductions occur sufficient to limit warming the Paris Agreement temperate goal of well below 2° C above pre-industrial levels, all available evidence points to the current winter drying trend continuing with the main uncertainty being how severe it will become.

30. TJ says that the description of future estimates of effect and impact as “projections” is a matter of semantics. Nevertheless, these are predictions only, based firstly on estimates of future temperature increases which may or may not occur, and then further on estimates of how such temperature changes may affect weather patterns, rainfall intensities, rainfall totals and rainfall distribution. All models are wrong, some are useful, is an important aphorism which numeric modellers need to keep in mind. The computer simulations which have been used to produce the climate projections noted above are based on theoretical mathematical equations which represent the current state of knowledge in relation to complex global weather systems. There is no guarantee that the predictions of these models are accurate, or will actually occur. At best, there is a probability that a certain outcome may occur. The historical data which climate scientists have collected and analysed generally support the statistical proposition that anthropogenic climate change is occurring. The best use of climate models is to extrapolate these data sets to determine future scenarios each of which depends on a number of parametric assumptions which are required to be input to such models. The effect of these potential scenarios on the natural and man-made worlds can then be assessed.

SIGNATURES

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