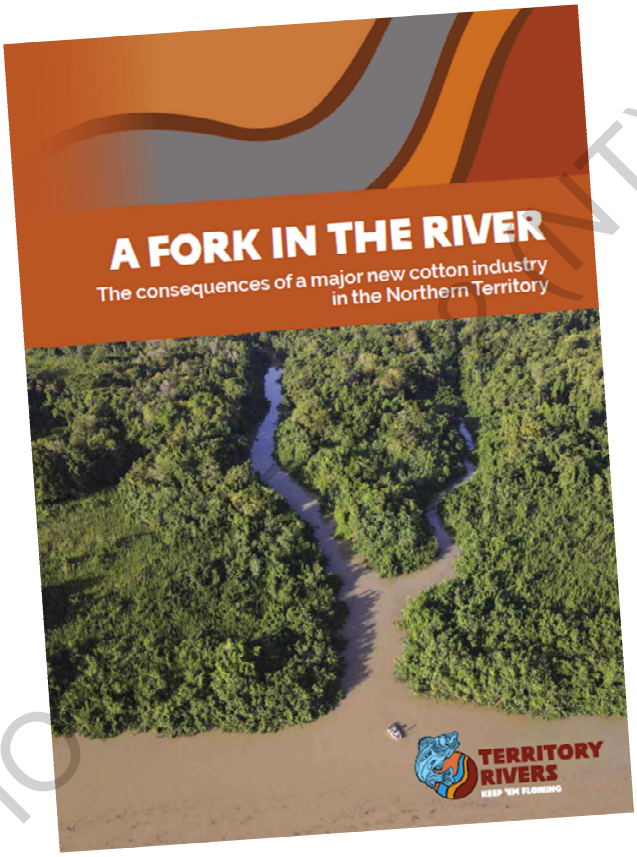
# Independent Peer Review of:

## A Fork in the River: The Consequences of a Major New Cotton Industry in the Northern Territory

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## Scope of Review and Deliverables

This document is an independent peer review (the Review) of the *A Fork in the River: The Consequences of a Major New Cotton Industry in the Northern Territory* report (the Report). The Report was produced for Territory Rivers: Keep 'em Flowing by the Centre for Conservation Geography. The Report covers the potential environmental implications of the expansion of the cotton industry in the Northern Territory, with a focus both on the Northern Territory generally, as well as the Daly River Region.

The scope of the Review is to assess (1) whether referenced statements in the Report are supported by the reference (or references) and (2) where appropriate, to determine whether the references used were selectively chosen/ used and suggest alternative or additional references. The purpose of the Review is to provide a 'fact check' of the use of literature in support of the statements made in the Report about the potential impacts of an expanded cotton industry in the Northern Territory.

The majority of the 184 references were readily available, however, some were private meeting notes that could not be accessed. Where readily available, the references have been collated (and provided with the Review). Where relevant, suggestions for other, equally credible sources are provided if disagreement exists or if clarification was required. These additional references are also provided with the Review.

The Review is structured as follows: Each section of the Report that contains referenced statements is included in the Review verbatim *in italics* (sometimes with clarifying points in [square brackets]). Following each sentence from the Report, comments are provided in indented non-italic font.

The Review concludes with an overall summary of the use of referencing in the Report and on the evidence base of the major points made.

# Contents

## Review of Introduction

*Australia's cotton industry has major ambitions in the NT, projecting a future of hundreds of thousands of hectares of cropping (mainly on pastoral properties) watered by billions of litres of water extracted from aquifers, rivers and floodplains [1,2].*

The combined area of the properties seeking development applications in [1, Table 4] is 175,000 ha. However, Table 16 in [1] projects a combined 77,000 ha (dryland + irrigated) from 2029 onwards. Report [2] flags plans for 10,000 ha in the Western Davenport region, 26,000 ha in the Wildman Agricultural Precinct, 60,000 ha of suitable land in the Douglas-Daly region, of which 20,000 ha is expected for cotton, with 45,000 ha for a mixture of crops that includes cotton.

Volumes of water required are not explicitly discussed in the reports. However, if the projected 22,000 ha of irrigated cotton is grown by 2029, and the 5-6 ML/ha irrigation rates from [1] are used, the statement on water use is accurate.

Floodplains are not explicitly listed as a water source; thus, this element of the statement is not completely supported by the references. The expectation will be that the majority of water used will come from a combination of rainfall and/or groundwater. It is unlikely that water will be extracted directly from floodplains. Floodplain maps are available at: https://depws.nt.gov.au/water/water-resources/flooding-reports-maps/floodplain-maps.

**Suitability of references:**
Statement reflects widely understood view of development of northern Australia. The strong interest in developing cotton in the NT is clear from the sources cited here, and elsewhere, e.g., Commonwealth of Australia (2015).

*In 2020, Australia's cotton crop was the smallest in 40 years, down by almost 90% on the 2018 crop due to the impacts of drought [3].*

This is an ABC article discussing cotton yields, Australia wide. The quote is from Cotton Australia general manager and is hence reliable. 2018 and 2019 were historically dry across much of Australia (i.e., http://www.bom.gov.au/climate/history/rainfall/).

**Suitability of reference:**
The low production years of 2019/20 are also discussed by the Australian Bureau of Statistics (2022a, b). The use of an ABC article is representative of the wider literature, but the Report could have cited ABS data.

*The climatic uncertainties and water constraints and costs in southern cotton growing areas are driving a strong push by growers to transform northern Australia into a major cotton growing province [4,5].*

References are both ABC articles. Climate is not mentioned in [4], and only mentioned once in [5], which is a statement about undeveloped land and the climate of the NT attracting attention of cotton growers. The "strong push by growers…" statement is inferred from these articles, based likely on the expressions of interest from investors listed in [5]. This point is not explicitly made in either article.

**Suitability of references:**
The interest in developing northern Australia is well known (i.e., Commonwealth of Australia, 2015) and the statement is widely accepted. As above, the reference is representative of the wider literature. The impacts of climate change on recent agricultural outputs (2001 to 2020) in Australia has been investigated by the Australian government, e.g., Hughes and Gooday. 2022.

*But the industry is ignoring the numerous government and CSIRO studies on the environmental constraints to cropping in the north [6–8]*

The cited documents [6-8] do document constraints to cropping in northern Australia. Whether these reports are being ignored is a judgement call on the part of the authors of the report.

Key quotes from [6-8] are presented below the highlight their content:

The majority of the mention of impacts in [6] suggest low to no impact from combination of climate change and development. Exceptions include the following discussion in relation to the Flora River:

"Dry season flows are poorly understood in this region therefore the ability to predict the potential impacts of climate and development on low or zero flows at environmental assets is very limited. Improved monitoring of low streamflow conditions is needed along with the development of hydrological models that combine surface and groundwater regimes. Further monitoring of groundwater levels is also required so that the potential impacts of climate change and development on groundwater-dependent ecosystems can be better understood".

And the Daly river:
"The Daly River has been described as a 'significant ceremonial track' by John Daly, Deputy Chairman of the Northern Land Council, the statutory authority representing the traditional owners of the region (Jackson, 2005). Impacts on the water table are perceived as a threat to the numerous sacred sites associated with the river. John Daly states that: "water usage as planned will not only expose these sites visually, but will also make them prone to destruction" (op cit.).

The journal article [7] states that "Estimates based on available physical resources and unconstrained by social, environmental, economic or legislative considerations". However, the discussion section of the paper concludes with the following:

"As with large dams, the development of these water-supply options would require trade-offs with other users of the water and the environment".

The report [8] includes the following:

"Because most rivers in northern Australia are ephemeral, these perennial rivers have high ecological significance. Any extraction of groundwater from these systems will most likely result in a reduction in streamflow at some point in time. The impacts of these reductions and whether those impacts are acceptable is a key management question".

**Suitability of references:**
The Report cites industry-led investigations into the potential cotton industry that do acknowledge the risks of negative outcomes to the environment, at least to some degree. Reference 1, cited elsewhere in the Report, mentions environmental outcomes as potential risks. The need to minimise environmental impacts is also mentioned in Reference 2, cited elsewhere in the Report. Thus, there is no issue with the selection of the references. The use of the content is generally accurate, although it is difficult to determine whether or not these reports have been 'ignored'.

*and downplaying the potential for major environmental, cultural and economic impacts [6,9–12].*

The cited references do highlight potential environmental, cultural and/or economic impacts.

**Suitability of references:**
Many of these references are highly reputable and from Government organisations including CSIRO and the Office of the Supervising Scientist However, the references do not explicitly make the point that these impacts are being 'downplayed', which is a judgement made by the authors.

*Previous proposals for large-scale cropping (focused mainly in the Daly River region) have also been constrained by public concerns about the impacts of land clearing and irrigation [9].*

Statement supported by the reference that documents the outcomes from a workshop on the environmental water requirements of the Daly River.

**Suitability of reference:**
Articles showing public support for land clearing and increased irrigation could not be identified. Thus, the selection of the reference is appropriate.

*These concerns remain. In a February 2021 poll of Territorians, 69% of respondents said the cotton industry shouldn't be allowed into the NT until they 'fix up their mess' in the Murray-Darling Basin [13].*

Statement from survey of 837 Northern Territory respondents from the seats of Blain, Brennan, Casuarina, Daly, Drysdale, Fannie Bay, Fong Lim, Johnston, Karama, Katherine, Nightcliff, Port Darwin, Sanderson, Spillett, and Wanguri.

The 'fix up their mess' statement is from Reference 13, however, the text in the questionnaire states to "fix the problems caused in the Murray Darling".

**Suitability of reference:**
The reference discusses the outcome from a questionnaire. We could not find equivalent alternative questionnaires to utilise.

*Rivers are important to Territorians – 63% of respondents said they use Top End rivers for fishing, boating or other recreation – and this poll indicates that the cotton industry lacks a social license in the NT*

The reference is not included, but this sentence also refers to [13]. This is the result of the same survey of 837 respondents mentioned above. The statement on lacking social licence is a judgement call made by the authors, inferred from this 2021 poll.

**Suitability of reference:**
The use of this reference for the first part of the statement is appropriate. The point on social licence isn't necessarily covered in the reference, although challenges in developing social licence are listed elsewhere, e.g. (KG2, 2020).

## Review of Cotton Growth Projections

*Plans for large-scale cotton cropping in the NT are rapidly gathering pace, with government-sponsored trials, interstate and international cotton growers buying up pastoral properties, and proposals for cotton gins [1]: Recent successful trials of growing cotton in the north have sparked significant interest from local and interstate growers and international investors... the industry is looking to significantly expand its cotton production.*

The sections of the quotes are taken verbatim from Reference 1. A cotton gin has been proposed, and the interest in growing cotton in the Northern Territory and the Ord is clear.

**Suitability of reference:**
The statement summarises the current interest in developing the cotton industry in northern Australia and the Northern Territory and is appropriate.

*The projected areas for cotton growing in the NT vary but range up to about 200,000 ha. Currently, the main focus is in the Tipperary, Douglas Daly and Katherine areas, including the 60,000-hectare Douglas Daly greenfield development [2].*

Reference 2 highlights the 60,000 ha that has been identified as suitable for agriculture. Reference 2 highlights that cotton is listed as one crop that is 'crucial in achieving this economic success'.

Of the 60,000 ha of land identified for agriculture in the Douglas Daly, between and 23,000 and 48,000 ha may be used to grow cotton, depending on how the values on page 27 of Reference 2 are interpreted. Cotton is not explicitly mentioned in the Katherine area in the report, aside from listing it as the likely site for a cotton gin. The origin on the 200,000 ha value from the Report is unclear from Reference 2 alone and thus the cited references do not fully support this statement.

**Suitability of reference:**
Utilising the values from Table 4 from Reference 1, properties seeking development applications make up 140,000 ha. While this value is less than the 200,000 ha listed here, the values are broadly consistent with the view that the projected areas vary.

*Other regions identified by the industry include the Adelaide River Valley, Roper Valley, Sturt Plateau and Barkly Tablelands (Table 1) [1].*

These locations are as listed in section 2.3 of Reference 1.

**Suitability of reference:**
These estimates were produced for NT Farmers to make the case for a Cotton gin. There is no reason to question that there is interest in developing cotton farming in these regions.

*In 2019, cotton industry proponents claimed that cotton production in the NT could reach about a quarter of a million bales by 2024 and eventually almost a million bales (Table 1) [1].*

Reference 1 lists many outputs or projected outputs of cotton:

- 400,000 bales 'in the next decade' (Executive summary)
- 4,500 harvested in 2019 (Executive summary)
- 250,000 bales by 2025 if second gin is built (Figure 1)

The likely source of the 'quarter of a million bales' figure is Table 3, where using all 2024 projections aside from the Ord equates to 246,470 bales.

**Suitability of reference:**
These projections are from a report to make the business case for a cotton gin. Using the values from Reference 2, 220,000 bales could be expected by 2024. These values are broadly consistent with estimates from Reference 1 (however, it is worth noting that they are both estimates).

*If we assume yields that are consistent with national figures [1,14] – about 10 bales/hectare for irrigated crops and 3 bales/hectares for dryland crops – with 80% dryland cropping (as predicted by the NT Government [15]), the 2024 forecast equates to more than 50,000 hectares of cotton and a long-term 'potential' of about 200,000 hectares.*

Assuming the 10 bales/ha for irrigated and 3 bales/ha for dryland cotton, and the 80/20 split between dryland and irrigated cotton (as supported by [15]):

The 50,000 ha '2024' figure would produce
(0.8×3 bales/ha× 50,000 ha) + (0.2×10 bales/ha× 50,000 ha) = 220,000 bales

The 200,000 ha 'Potential' figure would produce
(0.8×3 bales/ha× 200,000 ha) + (0.2×10 bales/ha× 200,000 ha) = 880,000 bales

Based on the assumptions made in the calculation, the areas required to be under cotton (assuming a single crop per year) are slightly conservative. The actual areas under these assumptions would be ~56,000 and ~206,000 ha.

**Suitability of references:**
The projected values appear reasonably consistent with other data sources, i.e., the Australian Bureau of Statistics (2022b).

*More recently, in its 2022–23 budget, the NT Government predicted 40,000 hectares by 2025, requiring a doubling of the area harvested each year [16].*

[16] predicts 40,000 ha of land to be used to grow cotton by 2025, and that 6,000 ha will be utilised by 2022. The '*doubling of the area harvested*' is a slight over-estimation of the rate). If there are 6,000 ha in 2022, doubling each year equates to 12,000 ha (2023), 24,000 ha (2024), and 48,000 ha (2025).

Assuming a linear increase in the area required, the rate of increase is ~1.88, thus the reference does not fully support the statement.

**Suitability of reference:**
The 40,000 ha value is reasonably conservative compared to other estimates of area under cotton, e.g., the 50,000 ha figure mentioned in the response above.

*A 2020 economic analysis by the NT Farmers Association also projects estimates of the likely cotton cropping area [2].The executive summary identifies 85,000 hectares for new agricultural development, including 62,000 ha for cotton, but the areas identified in the report for greenfield developments exceed 165,000 ha, with cotton described as the 'cornerstone' to their success. In particular, land clearing would be required for the following developments (for which cotton is one of the proposed crops) [2] (Figure 1):*
*• Douglas Daly Stage II – 62,000 ha across 4 pastoral properties (50,000 ha for cropping, with 23,000 ha for cotton)*
*• 3 proposed NT Land Corporation agricultural precincts:*
*• Keep Plains – 67,500 ha (Stage 3 of the Ord agricultural district)*
*• Larrimah – 2,180 ha (the area of suitable soils)*
*• Wildman – 26,000 ha*

The Executive summary in [2] lists 'plant-based agricultural and horticultural developments that will 'cover an area greater than 85,000 hectares (ha)' across the Wildman River, Larrimah and Keep Plain regions. The executive summary highlights a further "60,000 ha of suitable land available for development" in the Douglas Daly region (145,000 ha total, noting that the 85,000 ha figure included the qualifier 'greater than').

Areas listed in the report:

- Wildman (26,000 ha, requiring clearing, no cotton mentioned)
- Larrimah (5,712ha, 2,180 ha suitable soils)
- Keep Plains (67,500 ha fertile agricultural land)
- Douglas Daly II (23,000 ha for cotton, 50,000 ha for cropping, 62,000 ha total)

Adding the largest of each of the areas in the list above equates to ~161,200 ha, which is slightly less than the 165,000 ha value listed in the Report.

The 165,000 ha value from the report appears to be a slight overestimate, especially given that it is not clear whether land unsuitable for farming would be cleared and that the areas discussed are for agricultural developments more generally, not cotton specific.

**Suitability of reference:**
The cited reference relates to a broad range of plant-based and horticultural developments, rather than cotton cropping area specifically. Thus, the use of reference misrepresents the content of the reference. The values used here also round to the upper values.

*More than 20 NT properties have been identified, in industry reports or in the media, as potential sites for cotton growing (Table 3, Figure 2) [17–19].*

Reference 17 refers to Florina and Elizabeth Downs in the NT
Reference 18 mentions 'diversification model' of farming on Vermelha Station.
Reference 19 mentions Scott Creek station.

**Suitability of references:**
These references do not fully support the point relating to the 20 properties. The fact that the Report would present these references is odd given that the list of properties with intentions to grow cotton (Table 2) was sourced from a broad range of sources.

*They include several pastoral leases recently bought by large foreign cropping companies or interstate cotton growers. Interest has been surging among southern growers, whose existing operations are limited by drought and high water charges [1,17,19–21].*

The news articles in References 17, 19-21 typically discuss foreign investment. Reference 1 does mention interstate growers (page ii). The statements about drought and high water charges in other states (relative to the NT) does not appear to be explicitly mentioned in the cited references.

**Suitability of references:**
The interest in properties to develop in the NT is clear. For example, interested from southern farmers could be driven by drought-related factors (e.g., Hughes and Gooday, 2022) or the government white paper on developing Northern Australia (Commonwealth of Australia, 2015).

*A potential area of cotton cropping has been publicly stated for about half the properties, totalling more than 150,000 hectares (Table 2).*

The value is difficult to confirm from Table 2, with qualifiers including “up to” and “greater than (>)” used. Table 4 from Reference 1 lists 140,700 ha. However, this value is difficult to qualify given the qualifiers used on the values.

**Suitability of references:**
The area discussed here is not surprising, given the projections of areas to be under cotton cropping by 2024, i.e., Reference [1, 2].

*For best practice soil and pest management – to limit the evolution of pest resistance and loss of soil fertility – industry advice is to leave a cropped area fallow or rotate it with other crops such as fodder in a 2–3 year cycle [22–24].*

Statement supported by the references.

**Suitability of references:**
We see no reason to question companies such as Bayer on crop rotations and pest resistance.

*In the Daly region it has been estimated that annual dryland crop sowings of 100–400 ha require 300–1,000 ha of arable soils [12].*

Statement supported by the reference (page 65).

**Suitability of reference:**
The values from the reference are obtained from personal communications, rather than publicly available resources. An alternative and more easily verifiable source would be better to use in this case.

*In the eastern states, to manage high levels of pest resistance in cotton crops now requires longer rotation periods of 1 in 5–8 crops [24].*

**Suitability of reference:**
Reference relates to private meeting notes. This point could not be easily verified. An alternative and more easily verifiable source would be better to use in this case.

Extensive information of crop rotations for cotton are available from discoverable sources, including from the Cotton Pest Management Guide (CRDC and CottonInfo, 2021). An alternative reference, such as the one suggested here, in this instance could have been used.

*Another reason for crop rotation is that NT dryland cotton must be planted into a thick mulch layer to prevent surface soil crusting that prevents penetration by cotton seedlings [24].*

Reference relates to private meeting notes. This point could not be easily verified.

**Suitability of reference:**
Issues with soil crusting are discussed elsewhere, e.g., Yeates and Poulton (2019). An alternative reference such as would be beneficial in this instance.

*Refuge crops must also be grown alongside cotton – currently requiring up to 15% of the area of Bollgard 2 cotton crops and 7.5% of Bollgard 3 crops [22,23].*

**Suitability of references:**
The origin of the 7.5 and 15% values is unclear. References 22 and 23 seem to suggest refuge crops of 2.5 to 10% of the cropped area.

*Therefore, to meet the industry forecasts in Table 1 would likely require the availability of 100,000 to 150,000 hectares of cleared arable land in the short-term (2024) and potentially 400,000 to 600,000 ha in the longer term. [No reference provided]*

The bales/ha for all projections from Table 1 calculate out at between 4.34 and 4.5 bales/ha, which is consistent with the previous assumptions of 3 bales/ha for dryland cotton, 10 bales/ha for irrigated and an expectation of 80/20% split between dryland and irrigated cotton. What is not clear is whether refuge crops are considered in these calculations.

If refuge crops are not considered, then the productivity (bales/ha) is expected to decrease with the area of land under refuge crops.

**Suitability of reference:**
The estimate of up to 150,000 ha by 2024 is broadly consistent with projections listed in other references used in the Report, e.g. [1, 2].

*The industry and the NT Government claim that no more than about 20% of the NT cotton crop will be irrigated [15,25] and that irrigated crops will need only half the water used nationally for irrigated cotton [26].*

**Suitability of references:**
These are the figures listed in References 15, 25 and 26. The use of references is appropriate.

*From 2016–17 to 2019–20, the average water use for irrigated cotton across Australia was 7.3 ML/ha [27]*

For additional context, the Australian average water use for cotton in 2019-2020 for Australia was 6.92 ML/ha. The data for the NT over this period was 3 ML/ha. The 2020-2021 rates were 6.7 ML/ha for Australia and 8.1 ML/ha for the NT.

**Suitability of reference:**
Using ABS data is appropriate.

*If we apply the assumptions that 20% of the NT crop will be irrigated with an average 3.6 ML/ha, about 40 GL of water would be needed to irrigate 11,000 hectares (20% of the 2024 production forecast, Table 1). This is equivalent to almost 70% of the allocations already granted under licence to properties for which there has been interest expressed in growing cotton (Table 3), suggesting that the industry demand for water will inevitably quickly grow. [No references given, but relating to assumptions listed in paragraph]*

3.6 ML/ha × 11,000 ha = 39,600 ML.
Table 3 reports 61,300 ML.
39,600 ML / 61,300 ML = 64%

**Suitability of reference:**
The statement made here is reasonable, assuming that the parameters are correct, however, we note that 64% has been rounded up to 'almost 70%' here, slightly misrepresenting the original Reference.

*A major cotton-driven growth in water demand is implied by the industry's push to be allowed to harvest overland flows. In the Daly River region alone, the industry has mooted the harvesting of more than 500 GL of water from overland flows, as well as the use of groundwater, to grow cotton and other crops [2].*

Reference 2 does discuss capture of overland flows. It is also worth noting here that the Department of Environment, Parks and Water Security have a draft policy for wet season surface water take that is out for review at the time of writing which would be relevant here (if the policy is adopted).

**Suitability of reference:**
The reference highlights opportunities to capture water and summarises groundwater and climate of the Daly area.

*This is almost triple the current allocation of groundwater. Recognising the limitations of groundwater, the NT Farmers CEO Paul Burke has said [28]: We have no desire to pressure government to take more groundwater than is already nominated in the water allocation plan. What we do have a desire for is to be able to flood harvest ...*

Statements are taken verbatim from quotes in Reference 28.

*Simulations and recent field trials at the NT Government's Katherine Research Farm yielded 1–5 bales/ha for dryland crops compared to 5–10 bales/ ha for irrigated crops [29–31].*

The 1-5 bales/ha figure is as reported in Reference 29. Further explanations for the range are provided in the reference “the range due to differences in available water between soils, soil nitrogen availability including N fertiliser management, and the amount and type of soil much cover.”

Table 2 from Reference 30 shows average yields from cotton experiments. Irrigated yields reported in the same table supports the 5–10 bales/ ha value; however, the rain-fed yields reported ranged from 0.3 to 1.6 bales/ ha, were less than the 1–5 bales/ ha from the CSIRO experiments reported in Reference 29.

Reference 31 reproduced the same table as Table 2 from reference 30 and did not report any other yield figures in the article.

**Suitability of reference:**
Based on the abovementioned yields, the ranges presented in the Report seem broadly representative. In some cases, estimates on the high side. Although, it should be noted that modern cotton trials by DITT differentiate between purely rain-fed and predominantly rain-fed situations (DITT, 2022).

*But there is a very narrow sowing window for dryland crops – too early risks rain on maturing or open bolls, causing boll rot and fibre discoloration; too late and the crop becomes water stressed before the bolls are mature, reducing yield and fibre quality [32].*

**Suitability of reference:**
Reference 32 does not mention the ‘rot’, ‘bolls’, or ‘discoloration’ or aspects of crop quality. These points are made in Reference 29 (in section 2.2).

*Achieving acceptable yields requires a 140–150-day period of reliable rainfall [32].*

The mention of the 140-150 day period could not be found in Reference 32. It could be that the site is dynamic, and this refers to a previous version. The Report does not provide dates accessed, so this is difficult to determine.

**Suitability of reference:**
The source appears credible. We could not find a suitable alternative source for this statement. For example, the section on rain in the Australian Cotton Production Manual (CRDC and CottonInfo, 2022) mentions rain volumes rather than rain days.

*When this does not occur – for example, in a drier-than-average wet season or when there is no rain for several days – a crop can fail or yields are low [29], as noted by the project manager for NT’s cotton gin under construction [33]: Cotton takes about five months to grow and it only rains for 3.5 months. The yield is limited by the duration of the wet season.*

Impacts of rain on yields is included in Reference 29. The statement from Reference 33 is as reported.

**Suitability of references:**
Reliable sources used.

*The viability of dryland cropping has not been assessed in several of the proposed NT growing areas. In regions where the wet season is shorter or less reliable than in the Daly River region, irrigation may be necessary to achieve economic yields [29,31,34].*

**Suitability of references:**
This statement is reasonable given the References used here and elsewhere in the Report.

*The NT Government has indicated that cotton production in some areas, including Mataranka and Larrimah, would likely require irrigation [25].*

**Suitability of reference:**
Reference 25 (and others cited in the Report) note the potential need for irrigation, even for dryland cotton to 'finish the crop off'. Reference appears suitable.

*Irrigation is also likely to be required where soils have low water-holding capacity, soil types that are common in the regions proposed for cotton growing [29]. Cotton can become water stressed in just over a week without rain [29].*

**Suitability of references:**
Reference 29 highlights water stress can occur after 8-10 days, with severe stress after 15 days. There are numerous potential sources for this information, but these values seem reasonable.

## Review of Environmental Constraints and Impacts – Groundwater Constraints

*After all, water in the NT's rivers, creeks, aquifers and floodplains is already 'used' for many different purposes – sustaining human settlements, Indigenous cultures, recreation (especially fishing), tourism, extractive and agricultural industries, and nature [11].*

**Suitability of reference:**
The general sentiment of the statement is supported by the reference. Albeit, floodplains are only mentioned once in the document, and this is in reference to in stream dams. However, there is a general view that removing water from a system prevents it from providing some other environmental service, such as sustaining floodplain ecosystems, as inferred in this instance.

*There are 2 allocation plans operating in the Daly River region, for the following aquifers (Figure 3):*
- *the Katherine Tindall Limestone Aquifer WAP 2019–2024, with an ESY of 38 GL [53],*
- *the Oolloo Dolostone Aquifer WAP 2019–2029, with an ESY of 97 GL [54]*

The ESY for the Katherine Tindall Limestone Aquifer WAP (2019-2024) is ~38 GL, however the previous WAP (2016-2019 version) is cited here. The Oolloo Dolostone ESY is as listed in the plan.

**Suitability of references:**
It is reasonable to cite Water Allocation Plans here.

*There is no water allocation plan yet for the Mataranka Tindall Aquifer, but a 2012 draft plan indicates it has already been overallocated [56].*

**Suitability of reference:**
The report highlights that licence limits were above the average extraction limits at the time of writing. However, the report also highlights a 5-year review process, whereby licences can be reduced. Furthermore, there is a difference between over-allocation and overuse. i.e., a 2017 report highlights that usage was 24% of the volume allocated (DENR, 2017). Thus, this statement is true, however the Report does not differentiate between allocation and use. Thus, the statements are missing these additional contexts.

*Of great concern is that an estimated 72% of water granted under NT licences is from water sources with no water allocation plan [No reference]. These allocations therefore lack appropriate planning oversight, a rigorous and transparent scientific basis, and appropriate stakeholder and public engagement [57].*

The sentence here is supported by the reference (although the source of the 72% value is not cited).

**Suitability of reference:**
It is valid generalisation to state that allocations outside of Water Allocation Plan areas have likely had less scientific investigation and public consultation. However, this is not to say that all of these regions are poorly understood.

*The NT Water Allocation Planning Framework provides the overarching law and policy for the allocation of water, governed by the Water Act 1992 [58].*

The statement is supported by the reference (the NT Water Allocation Planning Framework).

*The National Water Initiative is an intergovernmental agreement providing a framework for water policy, signed by COAG (the Council of Australian Governments) in 2004. It commits governments to transparent statutory water planning 'in which there is adequate opportunity for productive, environmental and other public benefit considerations to be identified and considered in an open and transparent way' [59].*

Elements of the quoted text are contained in the document, but the version of the document that we obtained (Feb 2021) does not contain the phrase which appears to be presented as a quote.

**Suitability of reference:**
Citing the Productivity Commission is appropriate here.

*Water allocation plans (WAPs) apply to specific water resources within water control districts, and are intended to ensure that 'water is equitably managed to preserve quality of life and the integrity of the water dependent ecosystems' [60]. Under the NT Water Act, a WAP should ensure that 'water is allocated within the estimated sustainable yield to beneficial uses'. As WAPs have been developed after licences to take water were already granted, some WAPs are already over-allocated, particularly in the Daly Beetaloo Water Control District, which covers much of the Daly River Basin.*

The statement is true that some WAPs are overallocated. The Katherine-Tindall Aquifer WAP is another example.

**Suitability of reference:**
Appropriate reference, although, it is worth highlighting the difference between allocation and use.

*Estimated sustainable yield (ESY) is the principal limit in NT water planning to water extraction from a given region. It is not defined in legislation but has been specified in NT Government documents as [61]:*
*the amount of water that can be taken from a water resource without compromising: key environmental values, Aboriginal cultural values, ecosystem functions, the productive base of the resource, or declared water quality standards, criteria or objectives.*

**Suitability of reference:**
Quote is taken directly from the supplied reference, which is a document from the NT Government.

*The 80:20 rule is the 'rule of thumb' principle for establishing the 'estimated sustainable yield', requiring 80% of a water resource to be retained for environmental flows and a maximum 20% to be allocated for consumptive use. For groundwater, this requires that extraction for consumptive uses not exceed 20% of annual recharge. For surface water, it requires that no greater than 20% of flows in a given place at a given time are extracted [61].*

**Suitability of reference:**
The description provided here appears to be a description of the Top End water allocation policy (i.e., DENR, 2020). While the text is accurate, the incorrect reference was used.

*The Tindall Limestone WAP, for example, says 'there is insufficient information to determine environmental and cultural water requirements in the plan area' [64].*

Statement is supported by the reference. However, further work in the area has been conducted since the publication of the WAP, including Lamontagne et al. (2021), amongst others. Whether these subsequent investigations provide the required knowledge of the system is difficult to determine.

*The waters in the Daly Basin aquifers are relatively young in geological terms (30–500 years old), which means they are highly sensitive to over-extraction [65].*

**Suitability of reference:**
The Daly Basin would encompass a wide range of ages (i.e., Lamontagne et al., 2021, amongst other references), including young waters as indicated here. It is true that younger (or modern) waters are at increased risk of over-extraction and/or climate change, i.e., Gleeson et al. (2016). The use of the reference is appropriate, with other sources (i.e., highlighted here, supporting this).

*This risk was exemplified by declining groundwater levels in the Katherine region in 2018–20 after very low wet season rainfalls (the lowest on record) [66].*

Statement supported by Reference 66.

*Due to insufficient recharge, the 2020 allocations for license holders in the Katherine Tindall Aquifer WAP were cut by over a third [67].*

Statement supported by Reference 67.

*The ecological impacts of current water allocations are largely unknown. The effect on discharges to the Daly River are unlikely to be observable until many years after extraction – an estimated 23 years for key aquifers in the Daly, well beyond the timeframe of existing studies [68]*

**Suitability of reference:**
Statement supported by Reference 68. Statement made in the conclusion of the reference. The potentially large delay between groundwater extraction and impacts is well understood and widely documented.

*In 2018, water use was only 27% of the allocation under the Oolloo Dolostone WAP and 31% of the allocation under the Katherine Tindall WAP [54,62,67].*

Differences between allocation and use is common. The 31% value is clearly available in the Oolloo Dolostone WAP.

*The Mataranka Tindall WAP (in the Douglas Roper Beetaloo Water Control District) stalled from 2019 until early 2021, when meetings reconvened. A proposed WAP for the Jinduckin Formation and the Daly Basin management plan have not yet been initiated. [No references provided]*

The Mataranka Tindall WAP is under development (DEPWS, 2022).

*So, where does the cotton industry propose to source water from in over-allocated regions? The solution, according to industry spokespeople, is the extraction and storage of water during floods – 'What we do have a desire for is to be able to flood harvest' [28]. But this could compromise ecological processes of fundamental importance to river and wetland health (Section 3.2).*

Statement is a direct quote from the reference.

## Review of Environmental Constraints and Impacts – Proposed Floodwater Harvesting

*Tropical floodplains are highly biodiverse and productive ecosystems, and their seasonal inundation and drainage are thought to be 'the primary drivers of ecological processes in large floodplain rivers' such as the Daly [69].*

This statement is supported by Reference 69 and is broadly understood/accepted.

*Wet season flooding triggers a dramatic surge in primary productivity, providing 'the energy that fuels aquatic food webs'. About 60% of the fishes recorded in the Daly River, including barramundi and sawfish, use floodplain habitats [70].*

This statement is supported by Reference 70 and is broadly understood/accepted (exact percentage 59%).

*The increased food and habitat available during floodplain inundation is vital for the breeding and migration of many species, including fishes, turtles, waterbirds, frogs, file snakes and crocodiles [69,71].*

This statement is supported by References 69 and 71.

*With the limited availability of groundwater resources in the NT, cotton industry proponents have recently advocated capturing and storing flood waters [2].*

**Suitability of reference:**
The fact that storing surface water is of interest is supported by Reference 2. The point on limited availability depends on how 'availability' is defined. The volume available to be allocated is certainly limited in some areas, particularly in the Daly Region (i.e., see the Oolloo and Katherine-Tindall Water Allocation Plans).

*On floodplains, long engineered structures such as access roads, channels and levee banks can intercept and divert large volumes of water that would have otherwise flooded wetlands, flowed into waterways or soaked into aquifers [72]*

**Suitability of reference:**
This statement is supported by Reference 72. Other relevant scientific investigations about the potential impacts of floodplain harvesting in Australia are those from Kingsford (2000), Steinfeld and Kingsford (2011) and Brown et al. (2022).

*The NT Farmers Association claims that 520 GL of wet season water may be available 'for further agricultural and horticultural developments' in the Daly region [2]. This figure has been repeated numerous times in the media as the rationale for a major increase in water extraction to support a cotton industry [28,73,74]. It is more than triple the current water allocations in the Daly region (Table 4).*

The volume of water is listed in References 2, 28, 73 and 74.

*However, the claim that 520 GL is available is contradicted in technical reports by the CSIRO and NT Government [6,9]. It is based on a claimed regional 'runoff coefficient' (the proportion of rainfall that is converted into runoff) of 0.5 (with annual rainfall of 1,000 mm and a 20% potential capture rate) [2]. There is no evidence for a rainfall runoff coefficient of 0.5. The CSIRO's study on sustainable yields in the region references coefficients ranging from 0.03 to 0.3 in different parts of the catchment [5].*

All these statements are supported by the references cited.

**Suitability of references:**
A range of coefficients are available. According to the CSIRO report (Reference 6) the runoff coefficients range between 3 and 30%, while according to the Supervising Scientist report (Reference 9) the runoff coefficients range between 10 and 36%.

*Overland flows are not a separate additional source of water for they flow into creeks, rivers and aquifers. Modelling groundwater and surface water together is essential to prevent the problem of double dipping [75].*

**Suitability of reference:**
Reference 75 highlights the reduction in the potential for double accounting with respect to numerical modelling of the Daly River and Roper River catchments. This point is well known in a general sense, i.e., Winter et al. (1998) amongst other sources.

*Due to the highly permeable nature of soils across most of the Daly catchment, true overland flow rarely occurs, except after intense rainfall events. Most water spends part of its journey from where it falls to the nearest waterway beneath the ground [76].*

Direct quote from Reference 76.

*The numerous sinkholes characteristic of the region's geology provide a direct connection from the surface to an aquifer. The Tindall Limestone, in particular, is connected via many sinkholes and caves [1].*

**Suitability of reference:**
This point is reasonable and widely accepted, but this reference does not appear to directly discuss this. Alternative references to make this point are readily available.

*Wet season flow is essential for aquifer recharge, including in very wet years. The Oolloo Dolostone Water Allocation Plan states [54]:*
***Additional water that recharges the aquifer in wet years should be reserved to boost aquifer levels. …** Above average rainfall years are extremely important for topping up the aquifer and maintaining groundwater levels and discharge during drier, lower recharge periods. This is important for water management as it means that even though the aquifer is recharged each year, there will be periods in the future that may last for several years or more when groundwater levels will fall and river discharges are reduced. **Thus, there is a need to "bank" aquifer recharge in wetter than average years.** [Bolding added.]*

Quote in section 3.5.1 of Reference 54.

*Diverting large volumes of water from rivers and floodplains can have major impacts on wetlands that depend on overland flows to maintain their ecological character [77].*

**Suitability of reference:**
Statement supported by Reference 77. Numerous alternative sources could be used to make this point.

*In eastern Australia, floodplain developments have affected waterbird breeding, vegetation health, frogs, microbats and woodland birds [78,79].*

**Suitability of references:**
Statement supported by reference in section 3 of Reference 78, which cites multiple other references which could also have been cited.

*The risks of floodplain harvesting include failures to replenish some wetland habitats, reduced input of food and energy into the river channel, compromised access by fish to rich food resources and lower fish recruitment [80].*

Statement supported by Reference 80.

**Suitability of reference:**
Suitable reference used, co-authored by university and government employees.

*The NT Government is developing a 'wet season flow' policy to establish an assessment process for wet season extraction, whether from the river channel or floodplain. A consultation draft is expected by mid- 2022 [66].*

The draft wet season surface water take policy is currently out for consultation at the time of writing.

*Current licensing arrangements fall well short of the reform commitments made under the 2004 National Water Initiative [57,59], and the scientific foundations and governance capacity in the NT to regulate this practice are deficient.*

**Suitability of references:**
In addition to the supplied references, shortcomings relating to water management in the Northern Territory and the National Water Initiative are further discussed in Hart et al. (2020).

*Water allocation committees have highlighted the gaps in knowledge needed to predict impacts, including surface hydrology and the dependency of ecosystem functions on flood phases such as the first flush being a trigger for fish movement in the Roper and Daly rivers [62].*

**Suitability of reference:**
Statement supported by Reference 62. See 1.0 Record of Committee feedback.

*Because of high evaporation rates, the storage of flood waters would require large dams [6–8]. In the Daly region, the potential evapotranspiration rate of 1,942 mm is almost double the average annual rainfall (1,019 mm) [6].*

Rainfall and evapotranspiration values are as listed in the references. Thus, evaporation losses are expected to be significant from dams in the area.

**Suitability of reference:**
Values of evaporation appear consistent with other sources, i.e., BoM (2022).

*Storage in the Katherine-Douglas-Daly area would require a dam area at least 40% as large as the irrigated area (based on a conservative annual evaporation loss of 1 metre, depth of 3 metres and annual application of 10 ML/ha) [9].*

Statement is supported by the reference. See section “Northern Territory process for allocating water”.

**Suitability of reference:**
The values used within the reference are reliable and consistent with other sources, including from the Bureau of Meteorology, i.e., http://www.bom.gov.au/watl/evaporation/.

*A proposed alternative is managed aquifer recharge (MAR) – the injection of water into an aquifer for later use [9]. The NT Farmers Association has proposed the building of weirs on the Lower King River and Stray Creek for MAR storage [2].*

MAR is a well-known, and suitable alternative to surface water storage (limiting the impact of evaporation losses). The approach can be applied where the hydrogeological conditions are suitable. Weirs have been proposed at the sites mentioned in the Report.

*But these options are mostly not feasible for economic or technical reasons or would breach the NT Water Planning Framework's 80:20 requirements for the provision of environmental flows [81]:*
*• Lower King Ring and Stray Creek MAR options – not technically feasible because they are water discharge sites*
*• Upper King River MAR options – technically possible, but injection and extraction volumes are constrained by the 80:20 policy (even the smallest of 3 modelled scenarios, storing 6 GL/year, would breach the policy in most years); only economic for high-value horticultural crops such as melons and okra.*

The fact that the Lower King River site is not technically feasible is included in the Executive summary of Reference 81.

The Upper King River site is listed as technically feasible in Reference 81. The full 6,700 ML/y scenario (lowest considered) cannot be conducted with the current 80/20 rule for all times of the year (Table 7-4).

**Suitability of reference (additional context/ calculations):**
Using the available data from gauging station (G8140086, from http://www.bom.gov.au/waterdata/) on the King River, and the currently proposed contingency rules from the surface water take policy (5% of the 25$^{th}$ percentile of the wettest three months over a 50-year period, here from 1974 to 2021, noting a large data gap between 1987 and 2009) over the period from 1974 to 2021 where data are available for all months, would allow for 816 ML to be extracted during the wet season months. The draft policy also includes rules whereby scientific investigation can be used to extract volumes of water that exceed (or are less than) the proposed contingency rule.

## Review of Environmental Constraints and Impacts – Inadequacies of NT Water Management

*It is widely acknowledged that the NT's water management and planning frameworks are deficient and do not incorporate many of the reforms agreed to under the 2004 National Water Initiative [59,82–85].*

Limitations to approaches in the NT are listed repeatedly in [59]. References [82-84] are 5+ years old, however [85] is a recent, high profile example.

The quote from [59] can be considered here: "In relatively undeveloped and developing water systems, where the consumptive pool has not been fully allocated, governments should consider if allocations or reserves are appropriate as part of the water planning process". The response to this could be that consideration was made.

**Suitability of references:**
These references, amongst many others (i.e., Hart et al., 2020) could be used to make this point.

*The NT's frameworks are still in a developmental phase, and water planning, in particular, is deficient. More generally, the NT Government itself recognises [86]: …the need for substantial reform of the Northern Territory's environment protection framework. Reforms are long overdue*

*and critical to achieving a robust regulatory system that the community will trust to ensure the Territory's ecologically sustainable development...*

**Suitability of reference:**
While the direct quote was not found, there is mention for the need for reform and the need for a "robust system to protect the environment" in DENR (2019).

*Environmental law specialists consider the NT's water law and governance to be 'amongst the poorest in the country' – because of deficiencies in water planning (e.g. the lack of legislated requirements for planning or specified WAP content), sustainable yield estimates (e.g. the lack of a legislated definition, methodology and enforceability), annual allocations (the lack of a clear, legally binding and consistent methodology) and licensing (e.g. the 'very broad discretion' of the Water Controller) [87].*

**Suitability of reference:**
The Report accurately reflects the statements made by the EDO, and documents limitations in current definitions of key terminology and/or the quantification of important variables (including Estimated Sustainable Yields). NT water law limitations are also mentioned elsewhere, i.e., Hart et al. (2020).

*In a 2021 analysis, the Northern Land Council found that the NT has failed to meet the requirements of the National Water Initiative to provide secure water to meet environmental and other public benefit outcomes, address overallocated and overused systems, and recognise the needs of Aboriginal people [88].*

Statement supported by Reference 88.

*Past intentions for integrated planning have also not been realised. In 2002, cotton farming, dams, subdivisions and clearing were banned in the Daly Region until a sustainable land use plan could be developed [89]. Much work went into developing this plan in 2011–2014 [90], but it was abandoned by subsequent governments.*

Reference 89 reports that cotton growing or dams in the Daly River were "banned", and further approval for subdivision or clearing were "halted" until a sustainable land use plan was developed.

Reference 90 discusses that clearing guidelines (as of 2014) had been proposed, but not legislated, suggesting that they could be removed by future governments.

*NT water allocation decisions have been repeatedly criticised, with accusations of corruption, a lack of transparency, discrimination against Traditional Owners and inconsistency with science. The critics have included Indigenous groups, the NT Farmers Association and environmental organisations [59,83–85].*

NT Water allocation decisions are regularly and repeatedly criticised in the media. References include criticisms from Indigenous people [83,84] and environmental organisations [85]. NT Farmers are not explicitly mentioned in the articles [83-85].

**Suitability of references:**
Water allocation decisions are regularly reported and criticised in the media. These references could be replaced with many others.

*An independent review of water licence decisions commissioned by the NT Government in 2017 found numerous 'substantive issues', including the lack of a scientific foundation for some allocations and inconsistencies with the planning framework. Procedural errors were also rife [82].*

Reference 82 does outline an independent review of water extraction licences in 2017. The 'substantive issues' quote does not feature in the document. There are multiple mentions of procedures being developed or amended, but no mention of 'errors'. The lack of a scientific basis for some decisions (in this case the Ti Tree Basin) were identified (see Recommendation P2-5).

**Suitability of reference:**
The reference documents the implementation of recommendations relating to water management approaches. Elements of the statements in the Report go beyond what is mentioned in the reference.

*Large water allocations continue to be granted outside the governance and scientific frameworks provided by water allocation plans. Some allocations are based on poor or limited science and exceed what was later assessed as the sustainable yield [82]. While the NT Government has addressed these issues to some extent, recent decisions such as those outlined in Box 2 indicate ongoing flaws [85,91,92]. When water is overallocated, it is financially, socially and politically difficult to subsequently reduce the allocations [93].*

**Suitability of references:**
It is true that water licences are provided outside of Water Allocation Areas. The statement in Reference 82 is as reported in relation to the Ti-Tree Basin. Reference 85 relates to the approval of the licence for Fortune Agribusiness, which at the time of writing is in the courts. References 91 and 92 are news articles reporting on a 10,000 ML/y licence, which was ultimately cancelled. Reference 93 cites a report for the CRCNA. The reference, while accurately representing the text, should cite the reference used within the CRCNA report.

*The lack of a strong scientific foundation for major allocations outside water allocation plans, such as those granted to Tipperary and Singleton stations and the Larrimah Agricultural Precinct, and the poor performance in monitoring, enforcement and compliance [82,84,85,91,92,94] are of great concern in the face of pressures to allow large-scale extraction of flood waters.*

**Suitability of references:**
This statement is largely a view of the authors of the Report. The references used are to document examples where questions about the validity of the science were questioned. The list of references include some water licences that do not directly relate to the extraction of floodwaters, (including Singleton Station licence, Reference 94).

*Even in jurisdictions with a more mature water management framework than the NT and much greater capacity and resourcing, there have been systemic failures to counter the influence of strong irrigation lobby groups [95–98].*

**Suitability of references:**
Issues with water allocation/use in New South Wales are well documented. The references support this statement.

*The devastating ecological, social and cultural impacts of cotton farming in the Murray-Darling Basin have been due to poor planning and failures to regulate floodplain harvesting and the cumulative impacts of agricultural developments. Efforts to re-establish environmental flows in the Murray-Darling Basin continue to be undermined by poor compliance, corruption and the political challenges of rolling back water consumption [95,99].*

The articles discuss the complexities of increased water use efficiency and return flows to rivers. Political challenges, especially with water allocations during drought years are documented (Reference 99).

**Suitability of references:**
Neither article directly discusses corruption, although it is inferred, i.e., in 95 "The actual rules about how much water can be extracted are substantially influenced by some irrigators in the consultation process before plans are implemented".

*In 2015 Tipperary Station was granted an increase in their water license from 5.15 GL to 15.4 GL, then the largest single water allocation in the NT [84]. A government review found this decision to be problematic for reasons including the following [82]:*
*• The existing allocation was not being fully used, contrary to government 'use it or lose it' policies.*
*• The company had no existing capacity to use the allocated water, and no realistic projections for its use.*
*• There was insufficient evidence in government documentation to establish whether the data and assumptions used to base the ESY on 20% of recharge from Tipperary Station were appropriate.*
*• The allocation exceeded the estimates of sustainable yield for the area by 10% on what was already a highly questionable estimate not supported by scientific advice.*

The content in Reference 82 that relates to Tipperary Station requests a commitment to ongoing monitoring and investigations (See priority P3-1). Estimated Sustainable Yield is discussed five times in the review. The recommendation highlights the need for improvements in the use of scientific investigation in allocation planning, as well as with further investigations of various groundwater processes.

**Suitability of references:**
The references document the context of the Tipperary Station licence.

*The water was allocated from the Jinduckin Formation Aquifer, for which there is no water allocation plan declared or under development [100]. There has been no scientific modelling of this resource or studies to investigate the potential environmental and cultural impacts of this allocation.*

The Jinduckin Formation Aquifer does not have a dedicated water allocation plan. While extraction from the Jinduckin Formation is not explicitly discussed in either the Oolloo Dolostone Aquifer or Katherine-Tindall Water Allocation Plans, the hydrogeological unit is present in the region where each of these plans applies.

**Suitability of reference:**
While there is no issue with the reference, it is worth highlighting that there have been limited scientific investigations of the Jinduckin Formation Aquifer, for example, Symington et al. (2021) which was largely based on geophysics.

*In June 2021 a 10 GL water license for development of the 5,700-ha Larrimah Agricultural Precinct was revoked by the Health Minister (after the Water Security Minister revealed a potential conflict of interest) following an independent review which found that the allocation (granted outside a WAP) was inconsistent with the NT Water Framework's 80:20 rules [91], was not precautionary, did not consider climate change, used the wrong allocation rules, and relied on a technical report with significant shortcomings [92]. Further work has been completed, and the proponents have been encouraged by the NT Government to resubmit their application [101].*

The licence discussed here is located in the transition zone between the Top End and the Arid Zone (Reference 91). Reference 92 discusses the decision to revoke the licence, including that climate change was not considered and that the incorrect allocation rules were applied and that the precautionary approach was not used.

**Suitability of references:**
The three references used here are media articles. Given that they are used to highlight that events occurred, rather than establishing scientific facts, their use is reasonable.

*In April 2021, a water licence was approved (in 4 stages) for extraction of 40 GL a year from 144 bores for a 3,500 hectare horticultural development on Singleton Station, under the Western Davenport Water Allocation Plan [102].*

**Suitability of reference:**
The four stages of the water licence are documented in Reference 102.

*It came after the NT Government issued a guideline in 2020 allowing for destruction of up to 30% of groundwater-dependent vegetation in the Western Davenport area [103].*

Reference 103 states that "70% of the current extent of GDEs [Groundwater Dependent Ecosystems] in the Western Davenport Water Control District should be protected from negative impact". Negative impacts are defined within the guideline document for GDEs where the depth to water is less than or equal to 10 m, and for GDEs with depth to water of 10 to 15 m.

Depending on the monitoring approach used, it is true that negative impacts to these GDEs may ultimately lead to their loss/destruction, whereby once the issues are observed, it may be too late for the ecosystems to recover. However, the point that the guidelines allow for the destruction of 30% of GDEs appears to be an interpretation of the guidelines made by the authors of the Report.

**Suitability of reference:**
The reference is appropriate; however, the use of the phrase 'destruction' may be an over-reach.

*The licence was issued despite the Western Davenport WAP rating the risk of changes to future estimates of water availability as 'extreme' due to limited data and modelling uncertainties [85]. And although the WAP highlights the lack of knowledge about Aboriginal cultural values in the drawdown area as an 'extreme' risk, the licence conditions didn't include any requirements to protect Aboriginal cultural sites [85].*

It is true that there are large uncertainties in the understanding of water resources in the area. These uncertainties are being addressed through a project with the National Water Grid Authority.

**Suitability of references:**
Issues with lack of protection of cultural sites were raised by multiple participants in the review of the licence (Reference 104). Further details on the current understanding of the area are available in the model report for the area by Knapton (2017).

*After a review triggered by objections from Traditional Owners and environment groups [104], the licence was re-issued in November with revised conditions that include a detailed assessment of the aquifer, an impact assessment of cultural values and a referral to the NT EPA for assessment under the Environment Protection Act [105].*

Statement supported by the references (including a news article citing minister Worden).

## Review of Environmental Constraints and Impacts – Impacts on Water Quality

*Broadacre cotton farming is likely to reduce water quality, potentially risking human and ecological health – due to the industry's substantial use of fertilisers (eg nitrogen and phosphorus) and biocides (herbicides, fungicides and insecticides). These are discussed mainly here with reference to the Daly River region. Soil erosion and increased sedimentation from land clearing and cropping are also threats to the health of aquatic ecosystems [106] (see section 3.6).*

This statement is supported by Reference 106, section 4.4.

**Suitability of reference:**
More generally, the potential impacts of broadacre cotton farming on water quality are well documented in the literature. However, industry goals to improve river health (e.g., noted in Reference 2) may largely mitigate these impacts.

*In the Daly River region, the Oolloo Dolostone Aquifer and the rivers fed by groundwater are highly vulnerable to contamination [107].*

**Suitability of reference:**
There does not appear to be a mention that the Oolloo Dolostone Aquifer is vulnerable to contamination in Reference 107. However, there is abundant evidence that karstic aquifers can be highly vulnerable to groundwater contamination (e.g., Foster et al. 2013; Kahlor et al. 2019; Reberski et al. 2022). This is due to thin soils, focussed recharge points and potentially short residence times.

*Because recharge frequently occurs rapidly through sinkholes – thus bypassing the filtering effect of the soil – these highly transmissive systems can act as conduits for poor quality drainage water [108].*

This statement is partly supported by Reference 108.

**Suitability of reference:**
A more appropriate reference here would be Enemark et al. (2019). Rapid recharge into the subsurface through sink holes is well documented and accepted in the literature.

*Fertilisers, herbicides and pesticides leaking past the root zone are able to drain laterally through aquifers. The impacts of these chemicals on downstream ecosystems are, according to CSIRO studies, likely to be of great concern – particularly because of the very strong connectivity between the groundwater system and Daly River [108].*

The statement "particularly because of the very strong connectivity between the groundwater system and Daly River" is supported by Reference 108. The impacts of chemicals on ecosystems (the phrase 'environment and downstream users' is used instead) is discussed in Reference 108.

**Suitability of reference:**
The reliance on spring flow to the Daly is well documented. Thus, groundwater contamination in the area has the strong possibility to reach the river.

*The drainage of poor quality water into groundwater and then into the Daly River may also impact drinking water for towns and Indigenous communities downstream [108].*

**Suitability of reference:**
This statement likely refers to the statement "It is the fate of nutrients and agrochemicals used with irrigation that are likely to be of most concern to downstream ecosystems" on page 41 of Reference 108, thus is a suitable reference.

*Groundwater in the Daly River region has already been polluted, demonstrating its vulnerability to contamination [109–111].*

This statement is supported by Schult (2016) (Reference 110).

**Suitability of references:**
However, Reference 110 also mentions that both nitrate and pesticide concentrations did not exceed guidelines for drinking water or environmental protection. Thus, the use of this reference as presented is slightly out of context. The point that agricultural pollution can impact water quality is valid.

*The Tindall aquifer is contaminated with per- and poly-fluoroalkyl chemicals used for firefighting at the RAAF Base in Tindall, and the Oolloo aquifer in the Douglas Daly and Katherine areas has traces of pesticides and nitrates [112].*

Reference 112 does highlight groundwater contamination. The article also highlights that concentrations were below drinking water guidelines and well lower than in other parts of Australia

Further discussion on the use of this reference in the statement below.

*Government-funded surveys in 2018 found that [112]: nitrate concentrations were elevated under agricultural land, indicating that such land uses, likely involving fertiliser application, are having an impact on Oolloo aquifer groundwater.*

Reference 112 does highlight elevated nitrate concentrations. The article also highlights that concentrations were below drinking water guidelines and well lower than in other parts of Australia.

**Suitability of reference:**
Failing to mention the fact that concentrations are very low exacerbates the significance of the points made. The Report could have cited the original report or mentioned the fact that the results were viewed as “generally quite positive”. Thus, the reference appears to have been selectively used, as has its representation.

*Contaminants in groundwater will also impact water quality of the Daly River in the dry season, when it relies on discharge from groundwater. Government surveys have detected 9 different pesticides, mainly herbicides, in groundwater and dry season flows in the Daly [109].*

This statement is generally supported by Schult (2016), Reference 110, in the fact that groundwater contamination can influence surface water quality.

**Suitability of reference:**
However, the reference also mentions that none of the detected substances exceeded guideline values for moderately disturbed ecosystems. It appears that as presented, the reference has been misrepresented.

*Atrazine – ‘very toxic to aquatic life with long lasting effects’, according to safety information [113] – was the most common contaminant, found in 15 of the 25 bores tested.*

This statement is not supported by Schult (2016), Reference 110. Atrazine was detected in 2 springs and 8 bores, not 15. Schult (2016) found other triazines in 5 bores. This could be the source of the figure of 15.

**Suitability of reference:**
The point on the toxicity of Atrazine is valid. Further discussions about the toxicity for various exposure times are available elsewhere, e.g., the (US) National Pesticide Information Centre (2023).

*The potential for further contamination of the Tindall aquifer is of great concern as it forms part of the Katherine town water supply [110].*

This statement is supported by Schult (2016), Reference 110. The town of Katherine does rely on the Tindall aquifer for its water supply.

*Cotton farming in northern Australia requires large inputs of nitrogen. Tropical cotton growing manuals advise 38 kg/ha for optimal growth [32], but simulations of dryland cropping in the Daly River Basin, where soils are highly deficient in nitrogen, suggest that 100 kg/ha is needed to optimise dryland yields [29].*

The first statement is not supported by Reference 32. The second statement is supported by reference 29.

**Suitability of references:**
The low concentrations of nitrogen and phosphorus in soils of the Australian wet-dry tropics are well documented.

*Most commonly used nitrogen and phosphorus fertilisers are soluble, intended for use in sites where rainfall averages less than 600 mm or for soils that can retain these nutrients [114].*

This statement is supported by Reference 114.

**Suitability of reference:**
The statement above is valid; however, slow-release fertilizers are also available. i.e., Guo et al. (2020).

*Rainfall in potential cotton growing areas in the NT is much higher – averaging about 1000 mm in the Daly River region and over 800 mm in the Roper River region [114]. High rainfall makes it more likely that these nutrients will leach into groundwater and be washed into waterways [114].*

This statement is supported by Reference 114. Higher runoff coefficients are common where intense rainfall events occur, as is common in the Top End during the wet season. Under agricultural land use, this can potentially result in high nutrient loads into waterways.

**Suitability of references:**
Rainfall rates are reasonable for the Daly area, thus the statement reasonable.

*With naturally very low levels of nitrogen (0.004–0.04 mg/L) and phosphorus (>0.005 mg/L), the Daly River is highly susceptible to pollution by fertilisers [115].*

This statement is taken from reference 115. Primary reference is Rea et al. (2002).

**Suitability of reference:**
It is widely accepted that soils and waterways of the region have low concentrations of nitrogen and phosphorus, and therefore are potentially vulnerable to contamination.

*Nitrate contamination can lead to the eutrophication of aquatic ecosystems and cause algal blooms and other changes to the aquatic flora [110].*

This statement is generally supported by Schult (2016), Reference 110.

**Suitability of reference:**
However, the reference also mentions that in the Daly River, “the increased nutrients are taken up by biological processes in the river, apparently without resulting in a significant increase of nuisance algae or a change in plant biodiversity” (page 19). Here, there the use of the reference could be seen as selective.

*Nitrates can also cause human health problems if contaminated groundwater is used for drinking. They may be particularly harmful to young children and can combine with food to make cancer-forming compounds [114].*

This statement is supported by Reference 114.

**Suitability of reference:**
The impact of nitrate on human health is well documented.

*Extensive use of pesticides is essential for NT cotton crops, particularly during the wet season, when crop pests such as pink bollworm, looper caterpillars, Spodoptera and locusts are most abundant (see Box 3) [116].*

This statement is supported by Reference 116.

*Genetically modified cotton crops also require significant use of herbicides to manage weeds, defoliate cotton and manage fallow areas to prevent the development of pest resistance [32]. Because of the Daly's extremely permeable soil types and geology, cotton farming is likely to increase pesticide levels in groundwater systems and dry season flows.*

The first statement is supported by Reference 32. The increase in pesticide levels in groundwater systems and dry season flows will depend on the amount of herbicides

**Suitability of reference:**
The high permeability and/or connectivity of surface features (including sink holes) of the Daly region is widely reported. Low levels of pesticides have been detected in groundwater in the Daly area (below safe/ low risk levels), i.e., Schult (2016).

*All cotton grown in the NT will be genetically modified to be resistant to glyphosate [117].*

This statement is partly supported by Reference 117. The reference states that "genetically modified cotton could provide a basis for successful establishment of a cotton industry (…) in the Northern Territory".

*This herbicide is generally considered a non-persistent, relatively safe compound in the environment due to its rapid inactivation in soil [118], but it has been assessed as 'toxic to aquatic life with long lasting effects' [119,120].*

These statements are supported by References 118, 119 and 120. The correct Reference for 119 is https://echa.europa.eu/-/glyphosate-no-change-proposed-to-hazard-classification.

**Suitability of references:**
These points are further supported by other sources. e.g., toxicity and contact time are discussed in the National Pesticide Information (2023) Fact Sheet.

*Recommended biocides for growing dryland Bollgard3 cotton [32]:*
*• Sulfoxaflor (500 g/L), an insecticide for mirids, in December*
*• Diafenthiuron (500 g/L), an insecticide for silverleaf whitefly, aphids and mites, in February*
*• Pendimethalin (455 g/L), a herbicide, in October*
*• Roundup Ready® Plantshield® (690 g/kg glyphosate)*
*• S- metolachlor (960 g/L), a herbicide, in November, December and January*
*• Thidiazuron, Diuron and Ethepon, defoliants.*
*Recommended biocides for fallow management [32]:*
*• Glyphosate (450 g/L) in November and March*
*• 2,4-D amine (625 g/L) in November*
*• Flyroxyprin (333 g/L) in January*
*• Pendimethalin (440 g/L) in March.*

**Suitability of reference:**
This information could not be found in Reference 32. The source of this material is unknown.

## Review of Environmental Constraints and Impacts – Soil constraints

*Northern Territory soils are often considered poor for cropping, with low levels of nutrients and poor structure (low water-and-nutrient-holding capacity) [121].*

Reference 121 is NT Government webpage, *Resource management for growers*. This statement is taken directly from the reference.

**Suitability of reference:**
These statements are supported by various other sources including a technical bulletin by the NT government's Department of Resources (e.g., Smith and Hill, 2011), which also provides further details on the various soils in the NT and their characteristics.

*Many Top End soils are able to hold only 80–125 mm of plant-available water in the root zone [29].*

This statement is taken directly from the reference, although the original source of this information in not clearly identified Reference 29.

**Suitability of reference:**
A journal article by Dilshad et al. (1996) referenced older laboratory studies, and state that arable soils in the Daly Basin "have low water holding capacities", with water holding capacities ranging from 75 to 140 mm/m in Tippera soils and 40 to 75 mm/m in Blain soils. We did not find water holding capacities reported in more recent studies, e.g., Smith and Hill (2011).

*When actively growing, a cotton crop on soils with 90 mm of water will extract about 6 mm a day, initiate water stress avoidance in 8–10 days and suffer severe stress after another 15 days. Simulations indicate that growers would need soils with higher water availability for viable yields of dryland cotton [29].*

The first 2 statements are taken directly from the reference. Regarding the 2nd sentence about viability, the reference discusses yields rather than viability specifically, except for planting in early February, which Reference 29 states require soils with great than average water holding capacity to achieve acceptable yields.

Yield simulations were run for Tippera and Blain soils, with 79mm and 122 mm (Tippera) and 79 mm, 138 mm and 160 mm (Blain) available soil water at date sown. The 160 mm value is a hypothetical one accounting for the greater clay content of some Blain soils. For planting in early January, median yields under different water availabilities ranged from 2.09 to 4.75 b/ha, with lower yields in some years.

**Suitability of reference:**
The reference is appropriate given that it is recent, and focuses on cotton in the Northern Territory.

*A 2019 study of the potential for dryland cotton cropping in the NT identified 2 main suitable soil types in the Top End and on the Sturt Plateau: Tipperary clay loams and Blain sandy loams [29].*

Statement is supported by the reference, although the original source of this information is not clearly identified in Reference 29.

*The following characteristics of these soils (identified in a study of dryland yield potential) will nonetheless limit the viability of dryland cotton cropping or increase the likelihood of environmental impacts [29]:*
*• low fertility, particularly of nitrogen and phosphorous, but also of micronutrients and carbon*
*• mostly low plant-available water (80 to 160 mm soil depth) although some blain soils have higher availability (the better dryland cotton areas in New South Wales and Queensland have self-mulching clays with 250–350 mm of plant-available water)*
*• high susceptibility to surface crusting after ploughing*
*• risk of poor establishment (patchy stands or replanting required) due to high soil temperatures and soil crusting*
*• risks of erosion, particularly the Blain soils*
*• high soil temperatures, which could kill establishing seedlings*
*• a high risk of nitrates leaching below the root zone or being lost in runoff.*

The reference mostly refers to yields rather than viability specifically. The statements about soil characteristics are supported by the reference, although the original source of this information is not clearly identified in Reference 29.

**Suitability of reference:**
Detailed information about soils in the Northern Territory are also available at other sources, including from the NT Government, e.g., https://depws.nt.gov.au/rangelands/publications2/land-soil-vegetation.

*At all proposed locations the soils are highly deficient in available nitrogen. There is a limit to the extent that this can be rectified for cotton, with results showing only a marginal yield benefit with applications over 100 kg/ha, as water and climate factors limit the yield potential [29].*

The statement is generally supported by the reference, although “limit to the extent to which this can be rectified” is different to demonstrating no worthwhile effect of N fertiliser application.

**Suitability of reference:**
Yield simulations presented in Reference 29 do demonstrate marginal additional benefit of increasing fertiliser application from 100 kg N/ha to 150 N/ha, but ALSO show increases in yield resulting from N fertiliser application of between 50 and 150 kg/ha.

*Where the climate may be suitable for cotton in the Baines and Roper river catchments and the Barkley Tableland there are large areas of heavy clays [29].*

The statement is supported by the reference.

*Experience in the Ord and Burdekin regions has shown that lack of wet season trafficability and water logging are major constraints of cropping on clay soils [29].*

The statement is supported by the reference.

*2018 assessment of failures in past large-scale agriculture in the Top End (with a view to not repeating mistakes of the past) found that despite the constraints of soil type being known in some cases, suboptimal practices were still used and 'some soils risks were not considered or even ignored at the time', including secondary salinisation due to rising water tables [122].*

This statement reflects the assessment made by the authors of 122.

**Suitability of reference:**
Reference 122 cites Petheram et al., 2008, in which salinisation associated with specific developments – the Ord River, Katherine-Douglas-Daly region, and Lower Burdekin Irrigation Areas - is discussed. However, the specific interpretation is from 122.

*Given the water and other requirements (e.g. soil, slope, access), the land in the Daly region identified as having high potential for cotton is mostly concentrated in the Douglas River, Stray Creek and Fergusson River catchments [123], which means potentially intense pressure on local water resources and native vegetation.*

The statement generally reflects the assessment made by the authors of Reference 123.

**Suitability of reference:**
However, reference 123 seems to refer to agriculture more generally rather than cotton specifically, although this is somewhat unclear. Reference 123 uses the word "high" rather than "intense" to describe likely pressure on this area. Reference 123 also does not make the original source of this information clear.

*An NT Government report on the effects of agriculture on soils in the Daly region identified risks of erosion, loss of carbon, crusting, acidification and nutrient loss [124].*

Reference 124 reports on trials examining the effect of agricultural practices on soil pH and soil carbon in the Douglas Daly region. The trials showed changes in soil C and acidification over time. The other risks (erosion, crusting and nutrient loss) listed are from the introduction to Reference 124 and refer to another source – Smith and Hill (2011), which supports the statement by citing a range of sources.

## Review of Environmental Constraints and Impacts – Land clearing

*Approvals for land clearing on pastoral properties have surged more than 10-fold in the past decade, rising from an average of about 1,000 ha/year in 2010 to 2015 to more than 20,000 ha/year in the past 6 years, for a total exceeding 120,000 ha (Figure 5).*

The text refers to Figure 5, but the origin of the data in Figure 5 is not explained, neither in the main text nor the figure caption.

**Suitability of reference:**
Evidence to support this statement is lacking. No reference is provided for the area of land clearing approvals on pastoral properties.

*A significant proportion of recent clearing is either explicitly linked to cotton developments or likely to be in anticipation of future cotton projects.*

**Suitability of reference:**
Evidence to support this statement is lacking. No reference is provided.

*Cotton industry proponents claim that little additional land clearing will be required. The NT Farmers Association is promoting the idea that the industry can be developed 'on land that is already cleared and has been used for other crops' [125] and that there is 'enough cleared land already to kickstart the industry' [126]. But many properties mentioned in industry growth projections lack cleared land, and pastoralists with a publicly expressed interest in growing cotton have secured approvals or applied to clear about 20,000 ha since 2020 [127] (although not all has been specified as intended for cotton growing, Table 3).*

The assertion of the first sentence, that 'cotton industry proponents claim that little additional land clearing will be required' is supported by the media articles cited [125–126].

The assertions of the second sentence appear to be at least partially supported, but there is a need for a more detailed explanation of how some data were derived. Table 2 (that appears to have erroneously been referred to as Table 3) provides evidence that 'properties mentioned in industry growth projections lack cleared land', however the source of data on existing land clearing is not clear. A footnote to Table 2 states that historical (<2003 land clearing data come from 'a vegetation survey of the Daly region in 2012'.

**Suitability of references:**
Documentation of this survey is not formally cited in the Report. Discussions of clearing are available in other references cited in the Report, e.g., Reference 1 and references cited in Table 2.

*Cotton-growing proposals for just the 4 properties (Auvergne, Newry, Manbulloo and Scott Creek) listed in the NT Farmers' business case for the construction of a cotton gin [1] would likely require clearing of at least 80,000 ha (Table 3). But, as discussed in section 2.1, the area of cleared land required for cotton cropping is likely to be 2–3 times the area under cultivation in any given year to enable crop rotation and companion planting. If dams are required, additional clearing of up to 40% of the area under irrigation may be required [9].*

The first sentence seems to be justified, given the available information. It states that 'at least 80,000 ha' of clearing is likely to be required. This appears to be based on information in Table 2 (erroneously referred to as Table 3), i.e., an indicated cotton crop area of 25,000 ha plus 'up to 100,000 ha' (= 125,000 ha) minus land clearing (historical + permits + applications = 45,780 ha), to give 79,220 ha.

The second sentence is consistent with the discussion in section 2, which concludes that 'to meet the industry forecasts in Table 1 would likely require the availability of 100,000 to 150,000 hectares of cleared arable land in the short-term (2024) and potentially 400,000 to 600,000 ha in the longer term'. These figures are indeed 2–3 times the area under cultivation in Table 1 (56,000 ha [in 2024] to 206,300 ha [potential]). (Note: the reference to section 2.1 is presumably an error and should simply refer to section 2, as there is section 2.1).

The third sentence appears to be justified, based on a estimate in an Australian Government report on Daly River [9] (p. 32): 'Based on an evaporative loss of 1 $my^{-1}$ and a 3 m storage depth, the required storage area is equivalent to 40% of the area annually irrigated at 10 ML $ha^{-1}$ $y^{-1}$. However, this estimate of evaporation is very conservative … and should be revised upwards for a more accurate assessment.'

**Suitability of references:**
It is probably slightly misleading to say 'at least' 80,000 ha (in relation to Reference 1), given that the 100,000 ha cotton crop area was an upper bound. That said, it is also unlikely that all existing clearing would be included in the future cotton crop area.

*Clearing is of imminent concern in the Daly River and Sturt Plateau regions, where major cotton developments are proposed (Table 3, Figure 6). Already, more than 10% of the Daly Basin bioregion has been cleared [128] – 12% if all recent clearing permits are counted – and there are no controls in place to prevent more large-scale clearing.*

The first sentence seems justified, based on information in Table 2 (not Table 3) and Figure 6).

**Suitability of reference:**
The assertion of the second sentence, that 10% of the Daly Basin has already been cleared, appears to be inconsistent with the vegetation map in [128]. Our own GIS analysis of this dataset (available here: https://tinyurl.com/ecwbmy3b) suggests that the areas mapped as cleared or disturbed make up only 5.2% of the region (excluding areas mapped as water or the littoral zone, i.e., mudflats, samphire, mangroves). It is not clear how the report authors derived their estimate (10%).

*The Claravale Station pastoral lease and an adjacent freehold property, Claravale Farm, are part of the proposed Douglas Daly Stage II development that would involve up to 60,000 ha of land clearing [2].*

This is consistent with Reference 2, which states 'there is 60,000 ha of suitable land available for development' as part of Douglas Daly Stage II.

*The clearing on Claravale station could impact at least 8 threatened species detected on or near the land in question [129]:*
- *ghost bat*
- *partridge pigeon (eastern)*
- *Gouldian finch*
- *pale field rat*
- *Victoria River squat snail*
- *Mertens water monitor*
- *Mitchell's water monitor*
- *a rare bladderwort.*

The Australian Government's database 'Australia - Species of National Environmental Significance Distributions (public grids)' (https://tinyurl.com/mr46v4ry) shows the likely distribution of the EPBC-listed species (ghost bat, partridge pigeon, Gouldian finch) overlapping with Claravale station.

**Suitability of reference:**
The remaining species are NT-listed, but all could be present on Claravale station, based on the NT Government's threatened species fact sheet, or records of the species from the Atlas of Living Australia (www.ala.org.au).

*The impacts on some species could be significant. For example, the partridge pigeon population on Claravale Station is at the outer edge of the species range and may therefore qualify as an 'important population' under federal environmental law [130].*

This is correct. If the partridge pigeon occurs on Claravale station, it would be close to the edge of its range. The Australian Government's guidelines in Reference 130 state that important populations include those 'near the limit of the species range'.

*The impacts of large-scale land clearing include loss of biodiversity, soil erosion, degradation of water quality and riparian ecosystems, and carbon emissions [131,132].*

**Suitability of references:**
The negative impacts of land clearing on biodiversity and ecosystem function are extremely well documented. The two references chosen are good examples.

*Clearing destroys wildlife habitats, and as habitats become increasingly fragmented, populations of threatened species become more vulnerable to other threats, such as predation by cats and adverse fire regimes (exacerbated by gamba grass invasion), and lose the ability to recolonise suitable habitat [133].*

This statement is quite accurate.

**Suitability of reference:**
However, the reference to support it was a poor choice (i.e., web page of the Environment Centre NT). It would have been much more appropriate to choose one or more peer-reviewed scientific papers to support this statement. We suspect the reference to the ECNT website was an error.

*Land clearing contributes to climate change. The predicted greenhouse gas emissions from the proposed clearing of more than 20,000 ha on Maryfield Station in 2018 were an estimated 2–3 million tonnes, 15–20% of the NT's annual emissions [134]. The NT Supreme Court revoked a permit for this clearing due to deficiencies in the assessment process [134].*

These statements are accurate and consistent with the reference provided. The link between land clearing and greenhouse gas emissions is accurate.

**Suitability of references:**
However, it would have made more sense to reference the Supreme Court decision (https://tinyurl.com/a2kv7tc6), rather than an Environmental Defenders Office web page.

*In Australia, increasing evidence links deforestation from agriculture to weather extremes, including a hotter and drier climate, and increases in the duration and severity of droughts [135,136].*

This statement is well supported by the peer-reviewed scientific papers cited.

**Suitability of reference:**
There is much evidence that woody vegetation plays an important role in regulating regional-scale climate by enhancing evaporative cooling of the land surface, and numerous climate modelling studies have shown that extensive land clearing in the tropics can lead to regional-scale increases in temperature and reductions in rainfall (e.g. Bala et al. 2007; Alkama and Cescatti 2016; Wu et al. 2016). There appears to be little contradictory evidence in the published literature.

*International research suggests that 'even localised clearing might ultimately switch entire continental climates from wet to arid' [137].*

**Suitability of reference:**
The original source of the quote that 'even localised clearing might ultimately switch entire continental climates from wet to arid' is a peer-reviewed journal article, cited in Reference 137. Although this originally comes from a reputable journal, the hypothesis—that region-wide biomes switching could occur—is still quite speculative, without a lot of direct evidence. However, it is a reasonable statement to make, given the well-supported link between land clearing and regional climate (see previous point).

*An NT Government report found that agricultural land clearing and subsequent use can 'dramatically increase surface runoff' and increases the conversion of rainfall to runoff by up to 25% [11].*

Reference 11 supports this general statement that agricultural land clearing and subsequent use can dramatically increase surface runoff.

**Suitability of reference:**
However, we were not able to find where Reference 11 stated that land clearing 'increases the conversion of rainfall to runoff by up to 25%'.

*Severe soil erosion in the Daly River Basin followed cropping in the late 1960s [12].*

Reference 12 supports this statement.

*A recent major dust-storm in Katherine has increased residents' concerns about the potential impacts of large-scale land clearing on their town and its drinking water [28].*

This statement is an accurate reflection of this mainstream media article (ABC News).

*Soil disturbance and erosion from land clearing, tilling and rainfall have major riverine impacts. Removal of native vegetation alters soil and catchment hydrology, amplifies flood events and accelerates soil erosion, leading to increased sedimentation in waterways [115].*

Reference 115 supports this statement in regard to the Daly Catchment.

**Suitability of reference:**
The impacts of land clearing on erosion more generally are widely documented.

*The mean annual soil loss for undisturbed areas in the Daly River catchment is an estimated 0–2.8 tonnes/ha while the rate for tilled areas is 1.9–8.1 tonnes/ha [115].*

These figures accurately reflect those provided in Reference 115.

**Suitability of reference:**
These erosion rates are consistent with those reported elsewhere for the Daly area, i.e., Lal et al. (2020).

*Other hydrological impacts include reduced groundwater recharge, reduced baseflow discharge and increased incidents of fish kills [11,12].*

These impacts are all referred to explicitly by both Reference 11 and 12.

*Likely impacts on riparian and wetland habitats from reduced recharge are noted in section 4.1. Wetland loss due to land clearance for cropping has been a major problem throughout eastern Australia [12].*

It is well known that wetlands throughout southern and eastern Australia have been severely impacted by land clearing. Reference [12] supports this statement.

## Review of Environmental Constraints and Impacts – Climate constraints and climate change

*The rainfall in regions where cotton farming is proposed is highly variable year to year and also over longer periods – there are runs of very wet and very dry periods in the climate record spanning several years to decades [54].*

Reference 54 is the Draft Oolloo Dolostone Aquifer Water Allocation Plan 2019-2020. The statement that rainfall is "*highly variable from year to year*" is supported by the reference 54. Regarding the 2nd statement, the wording in Reference 54 is *"there are wetter and drier trends in the climate record on the order of decades".* Reference 54 presents annual rainfall totals as well as cumulative deviations from the mean, which do show extended periods (up to several decades) where the deviation from the mean decreases or decreases over the long term.

**Suitability of reference:**
The interpretation of "*runs of very wet and very dry periods...spanning several years to decades*" requires additional supporting information, including defining the terms very wet and very dry, which are open to interpretation. The more general interpretation of northern Australia exhibiting substantial interannual rainfall variability, including on several years to multi-decadal scales, but with variability declining from south to north, is supported by other sources (e.g., Sharmila and Hendon 2020).

*Variability over shorter periods, including the transition between the wet and dry seasons, can also be a problem. Dry periods of several days to several weeks in the middle of the wet season can significantly reduce yields of dryland cotton [11].*

The statement in Reference 11 is more qualified. Referring to rain-fed agriculture (more generally than cotton specifically) during the wet season, Reference 11 states "dry periods of several weeks may limit yields in some years."

**Suitability of reference:**
A broad range of factors could be considered here. Reference 29 (Yeates and Poulton, 2019) states that “a soil providing 90 mm of water will extract approximately 6 mm of water per day when actively growing”, so during a dry period after rainfall, the plant will “begin water stress avoidance in 8 to 10 days” and will begin severe stress “after another 15 days”. Decreased yields can also be caused by other forms of stress caused by water logging and/or reduced sunlight availability during overcast conditions throughout the wet season (Twine and Redfern, 2021) or extreme heat (Anwar and Darbyshire, 2017).

*Even for irrigated crops, climatic events in northern Australia lead to the abandonment of about 10% of crops [32]. The rate of abandonment of dryland crops is likely to be even higher.*

**Suitability of reference:**
Reference 32 is a CottonInfo brochure. The first statement is supported by Reference 32, although the reference does not provide the original source for the value. The 2nd statement that "the rate of abandonment of dryland crops is likely to be even higher” is not addressed in Reference 32.

*The weather affects access to fields crop establishment and growth early season weed control , insect pest pressure and transport to market [10].*

Reference 10 is a Cotton CRC and CSIRO review and scoping study for Northern Australia. Reference 10 does make these points, although reference 10 does not explicitly present information on weather impacts on transport to market for the NT.

**Suitability of reference:**
Reference 10 also states that the lighter textured soils that dominate the Daly Basin and Sturt Plateau will provide superior trafficability and is less likely to affect operations (i.e., that these are benefits, which are not mentioned in the Report).

*The variability is likely to result in major reductions in predicted yield, lower prices due to reduced quality, and challenges for wet season cropping [10,29,138]. These pressures may lead to larger areas being cultivated or require more irrigation to ensure economic yields.*

Reference 10 is a Cotton CRC and CSIRO review and scoping study for Northern Australia, Reference 29 is CSIRO Climate assessment and yield simulation, Reference 138 is journal article review of Cotton CRC research. The first statement is generally supported by the references as far as they present evidence of potentially large differences in yield and impacts to quality from rainfall and temperature variability.

**Suitability of references:**
The references do not appear to use the wording "likely to result in major reductions”. The 2nd statement is not addressed in the references cited in the previous sentence.

*Climate change predictions for northern Australia include rising temperatures, a higher frequency of hotter-than-average days, an increase in the number and severity of extreme rainfall events and a rise in the potential evaporation rate [139].*

This statement is supported by Reference 139. Regarding "an increase in the number and severity of extreme rainfall events" Reference 139 does not present projections for extreme rainfall but does refer to IPCC statement of there being an increased risk of extreme climate events under future warming.

**Suitability of reference:**
The statement is well supported by other sources, including the more recent summary provided by CSIRO and Bureau of Meteorology (2015).

*Projections for the Australian monsoon are highly uncertain, with about half the models predicting an increase in rainfall and half predicting a decrease [140]. Some predictions are for severe decreases.*

This statement is supported by Reference 140.

**Suitability of reference:**
This statement is supported by Reference 140. Other sources (e.g., Dey et al., 2019) also mention the lack of consensus among models regarding the projected mean precipitation trends.

*A 2008 CSIRO assessment of water resources in the Daly predicted median groundwater levels in the main carbonate aquifers would drop, reducing discharge by 14–22 GL/year, including from the Tindall Limestone aquifer into the Katherine River [6].*

Reference 6 is from 2009. This statement is supported by Reference 6. The prediction specifically includes future climate AND potential future groundwater development.

*For the Oolloo Dolostone aquifer, the predictions varied considerably under different scenarios – discharge decreasing by up to 43 GL/year under an extreme dry climate scenario and by about 9 GL/year under the median scenario, and increasing by up to 60 GL/year under an extreme wet weather scenario [6].*

This statement is supported by Reference 6. The prediction specifically includes future climate AND potential future groundwater development.

*Australian cotton production is likely to be impacted in complex ways by several aspects of climate change – reduced water availability, rising atmospheric CO2, higher temperatures and higher vapour pressure deficit [141,142].*

Reference 141 is a CRDC presentation. Reference 142 is a journal article simulating response of cotton in southern Queensland and Northern NSW to climate change. The statement is a general one and is supported by the references.

**Suitability of references:**
However, the references do not go into further detail about the implications of climate change predictions on the cotton industry, including “potential increase in heat stress and waterlogging, faster crop development” and pest, disease and weed-related issues (e.g., Luo et al., 2016 provides a cotton focused study).

*In eastern Australia, models mostly predict less favourable growing conditions and declining yields with a greater risk of extreme low yields [142].*

This statement is supported by Reference 142. In Reference 142 The yield simulations are presented as a range in the reference to account for variability in climate parameters and cotton response, but the interpretation of "mostly predict less favourable growing conditions" is consistent with the predictions for median yield and with the reference authors' own assessment. Regarding, "greater risk of extreme low yields", the wording is the same as in the reference and presumably refers to the yield estimates for 2050, which, reading off the figures/graphs appear to be close to 0 bales/ha at some locations for extreme low end of the range of predictions.

**Suitability of reference:**
Alternatively, Anwar et al. (2020) found that "projected future temperature and rainfall change with later planting dates, primarily resulted in a positive effect on yield by extending the time for rain-fed cotton growth", providing a potential effective management strategy for some cotton growing regions in eastern Australia.

*Climate change impacts on the natural environment are likely to be severe – a 2021 study by 38 scientists found that the tropical savannas are one of 19 Australian ecosystems at risk of collapse – 'potentially irreversible change to ecosystem structure, composition and function' – due to global climate change and multiple regional human impacts [143].*

This statement is supported by Reference 143.

**Suitability of reference:**
Additionally, a previous review paper on droughts and the ecological future of tropical savanna vegetation (Sankaran, 2019) did not explicitly mention the risk of collapse for tropical savannas, but stated that impacts of droughts are "already evident, with vegetation dieback reported from a range of ecosystems, including savannas, in recent years".

*Preventing land clearing and limiting water extraction will be essential to optimise the resilience of the savannas to climate change impacts [144].*

Reference 144 is the WWF's and ECNT's Action plan to conserve the Daly River as a living river. This statement matches the recommendations of Reference 144, although the reference recommended, at the time of publication in 2007, tightly limiting rather than preventing land clearing. Reference 144 makes limited use of published papers and reports. However, the principle of limiting land clearing and water extraction in order to protect values such as biodiversity is well established.

**Suitability of reference:**
Another reference used elsewhere in the Fork in the River report (Reference 143) lists both water extraction and habitat loss (including from land clearing) as pressures on Australia's savannas and could have been cited here.

## Review of Environmental Constraints and Impacts – Impacts on fisheries

*The discharge of waters from rivers is an important driver of the productivity of estuarine and coastal fisheries [145] and there are strong positive relationships between streamflow and catches of species of commercial and recreational importance, including barramundi and prawns, which can be compromised by water extraction [146,147].*

Reference 145 supports “quantitative evidence that freshwater flows to estuaries are crucial in supporting barramundi productivity”. References 146 and 147 do support that claims made. The results of 146 have now been published as a peer-reviewed paper (Crook et al. 2022).

**Suitability of references:**
References that better support points where 145 is cited and for other fisheries have been added to the references (Jardine et al 2011 and Warfe et al 2011). A range of other references not cited in the Report also support the claims (Robins et al 2005, 2006; Broadley et al 2022) and we are aware of no other published studies that would dispute the stated claims.

*Exemplifying the vulnerability of barramundi, a poor wet season in 2019 resulted in a ‘failed recruitment event’ and the lowest barramundi catch on record [148]. Other species were also badly affected – bony brim, mullet, tarpon and catfish.*

This reference supports the statements, but the source is an ABC news article is not peer-reviewed literature. However, the source of the material of the ABC article is actually a report that includes authors from Charles Darwin University, the Tjuwaliyn-Wagiman Aboriginal Corporation and NT Government staff, King et al., 2021.

**Suitability of reference:**
The point that barramundi recruitment is strongly linked to wet season flow is supported by a range of literature cited in the previous response; namely Crook et al. 2022.

*The abundance of barramundi is regulated by ‘a complex array of environmental factors and ecological processes’ [149].*

This is a quite general statement, but it is supported by the reference “...abundance of predatory fishes (noting the study was focused on barramundi) can be related to both recent abiotic (flow) conditions and the abundance of prey (biotic conditions) and provides strong support for the importance of bottom-up trophic dynamics.”

*Recent scenario modelling predicts that water extraction from the Daly and Roper rivers in both wet and dry seasons could have ‘strong’ negative impacts on barramundi recruitment [146].*

This reference supports the statement and as stated previously is now in the peer-reviewed literature (Crook et al. 2022).

*In the Daly, under scenarios of 20% extraction, declines in year- class strength were predicted to exceed 20% for dry season extraction in high-flow years and 25% for wet season extraction in low-flow and moderate-flow years [146]. Extraction of 40% of wet or dry season flows could result in declines of year-class strength by 40–50%.*

Reference 146 supports the statements and as stated previously is now in the peer-reviewed literature (Crook et al. 2022).

**Suitability of reference:**
However, the Report does not mention that under strong wet seasons, that wet season water abstraction of 10-20% had much smaller, to no measurable effects on

recruitment and that wet season abstraction on the receding hydrograph limb had much smaller effects. Thus, the Report has selectively used the reference.

*Studies in NT rivers have identified 3 different barramundi life history strategies: some live mainly in coastal and estuarine habitats; others migrate into a river as juveniles and return to the estuary after a few years; and others remain in a river for many years, returning to the estuary only as large females [150].*

The reference supports the statement.

**Suitability of reference:**
We are aware of no other published studies that would dispute the stated claims.

*Water extraction could alter the frequency of these life history strategies. If, as a result, more barramundi adopted the slower-growing, estuarine life strategy, 'the productivity of barramundi fisheries and their ability to sustain fishing pressure may be adversely affected' [150].*

Given that freshwater inflows into estuaries influences the number of barramundi that enter freshwater environments according to the literature cited, this statement is accurate and there is strong evidence that freshwater environments facilitate much faster growth of barramundi.

**Suitability of reference:**
Another more recent reference for this is Roberts et al. (2019).

*Barramundi would also be impacted if lower flows reduced the abundance of their important prey species (fish and crustaceans) [149].*

Reference 149 supports the statement, and we are not aware of any literature suggesting that water abstraction would increase food availability for barramundi, except in certain situations where impoundments and immediately downstream of dams can create novel environments that provide good feeding opportunities for some long-lived and large-bodied species of fish. However, these new feeding opportunities in and around some dams likely do not mediate the adverse population-level effects caused by river regulation.

**Suitability of reference:**
There is some evidence (see Arantes et al, 2019) that certain species of predatory fish that are adapted to lakes or slow-flowing rivers can experience greater feeding opportunities downstream of dams; however, given the likely impact of dams on reproduction of diadromous barramundi, an increase in food for adults would still probably result in population decline.

*Conversely, altered flows could increase the predation pressure by barramundi on certain prey species [151].*

The cited Reference (151) instead cites Turschwell et al. (2019) to make the claim. So, the original citation should have been Turschwell et al (2019), which generally supports the statement.

*Predicting such impacts is difficult because there is scant information about the flow-related ecology of most NT fish species [151].*

**Suitability of reference:**
Many aquatic ecologists would agree generally with this statement, but the reference cited doesn't appear to support the specific details and therefore this claim can be viewed more as an opinion of the authors of the Report.

*However, there is increasing evidence that significant water extraction during any season is likely to impact some species – a recent study in the Daly found that fish spawning occurs 'throughout the hydrological phases, throughout the full extent of catchment and in differing hydrological classes' [152].*

Reference 152 is accurately cited and a good example that supports the claim.

**Suitability of reference:**
This statement is supported by a substantial literature base which could/should have also been cited (e.g., King et al. 2015; Crook et al. 2020, etc.).

*The sensitivity of prawns to altered flow regimes is indicated by the complete lack of juvenile prawns in the Ord River subsequent to its damming [153].*

**Suitability of reference:**
The cited reference (153) instead cites Kenyon et al. (2004) to support the claim: "For example, anthropogenically altered freshwater flows in the JBG's Ord River likely explain why no juvenile prawns occur in the Ord River (Kenyon et al., 2004)"; nevertheless, the validity of the statement appears to be supported by Kenyon et al. (2004).

*Scenario modelling for 3 rivers in the Gulf of Carpentaria predicts a 'proportional decline in banana prawn catch' if flows are reduced [147].*

The reference cited and quotes are accurate and reported in context.

*Overall profits for prawn fishers could decline by 7–12% for at least half of the time if the currently granted entitlements for irrigation and the planned allocations are extracted from these 3 rivers [154].*

The reference cited is accurate and reported in context. The text from the report is presented here: "Results suggest that (without reallocation of fishing effort) vessel level business profit could reduce by between 7% and 12% for at least half of the time if currently granted entitlements and planned allocations were extracted from Gulf rivers, or by around 22% for at least half of the time if major dams are constructed in the Mitchell River in addition to granted entitlements and planned allocations. "

**Suitability of reference:**
Impacts from reduced flows on prawn fisheries are widely reported in the literature.

*Past proposals for broadacre cropping in the region have sparked major concerns from residents about the impacts of irrigation, land clearing and use of agricultural chemicals [12,89,115,155]. There is considerable wariness that the mistakes of the Murray-Darling Basin will be repeated in the Daly River region [93].*

> Community concerns are documented in the cited references. This information is available at a range of sources. Additionally, the point on the Murray-Darling Basin is included on page 13 of Reference 93.
>
> **Suitability of references:**
> Strictly speaking, this point depends on how 'community' is defined. i.e., there is also support amongst farmers both in the region, and elsewhere in Australia in developing broadacre cropping in the Daly Region. For example, this was the focus of a project by the CRC for Developing Northern Australia, which had a broad range of participants (Biggs et al. 2022). However, the overarching point made is supported by Reference 93.

*In the early 2000s, efforts were made to halt development pressures until holistic land use planning and catchment management could be implemented [115].*

> Reference 115 supports this statement. The article discusses Integrated Catchment Management in the Daly River Catchment.

*The NT Government imposed a moratorium on major developments in the central catchment, pending completion of an integrated regional land use plan. In 2011, the government initiated integrated catchment management planning, but this was not implemented due to changes in government [90,156]. The lack of such planning leaves the catchment vulnerable to cumulative degradation as development pressures increase [no reference provided]*

> Reference 90 states that the clearing guidelines were not legislated which appears to still be the case. A clearing moratorium declared in the Daly River region in 2003, that the moratorium was extended in 2007 and that the moratorium was formalised in 2008 (DEPWS, 2021). Reference 156 provides an overview of Daly River Management Advisory Committee from 2011.
>
> **Suitability of references:**
> The references do not capture the point that much of the area around the Daly is currently fully allocated and that clearing without access to water may not occur.

*While the river catchment is considered to be generally healthy, some tributaries subjected to intensive agriculture, particularly Green Ant Creek, have already suffered degradation [12].*

> The degradation in Reference 12 refers to "severe soil erosion" and that vegetation only remains along "riparian strips".
>
> **Suitability of reference:**
> Land clearing impacts have been documented for Green Ant Creek in other ecological risk assessments, i.e., Schult and Townsend (2012), amongst others.

*The Katherine River, the major contributor to the Daly River, is also under pressure due to cumulative agricultural impacts [12].*

Reference 12 supports this statement. On page 84, Reference 12 states that "the Katherine River, is also under some pressure, and cumulative impacts need to be considered".

*The Oolloo Dolostone WAP acknowledges that [54]:*
*Future development has the potential to place increased pressure on the river system through direct impacts caused by water extraction and from indirect impacts arising from native vegetation clearing and land use activities. This and the environmental and Aboriginal cultural significance of the Daly River, requires ongoing planning and community engagement to ensure that outcomes reflect social, economic, Aboriginal cultural and environmental values.*

Quote is as presented in Reference 54.

## Review of Values at risk in the Daly River Region – Natural values

*The Daly River is the largest perennial river in the Northern Territory, with a dry season flow 5 times larger than any other NT river [157], sustaining vast wetland areas and unique ecological communities [108].*

**Suitability of references:**
Reference 157 does support the claim, as does Petheram and Bristow (2008); Reference 108 does support the claim but mostly by citing DIPE (2003) and Price et al (2002), which states the Daly supports unique ecological communities

*The catchment is recognised nationally and internationally for its high ecological, cultural and scenic values. In the upper catchment lies World Heritage-listed Kakadu National Park and Nitmiluk (Katherine Gorge) National Park. Extensive parts of the Daly and Katherine rivers are listed as nationally important wetlands [65] and the estuary and lower floodplains meet criteria for listing as a Ramsar Wetland of International Importance (based on the abundance of waterbirds) [65].*

**Suitability of references:**
Reference 65 supports both statements, but the last statement is better supported by Chatto (2006).

*During the 8-month dry season, when surface runoff is negligible, inflows from a complex set of aquifers are continuous along most of the river length. These groundwater flows sustain abundant and diverse wildlife, including 90 fish species and 8 freshwater turtle species [158].*

Reference 158 generally supports this statement, except it states that there are 42 fish species.

**Suitability of reference:**
However, more recent references put the number at 90+ (e.g., Pusey et al., 2020, as well as stating "Maintenance of alkaline groundwater flow is critical during the dry season, giving the River a period of respite while the water is highly buffered and metals unavailable".

*Species likely to be impacted by water extraction include the pig-nosed turtle, listed by the IUCN as endangered. The Daly River population is recognised as the largest, least impacted and most significant for this species [54].*

Reference 54 supports this statement.

**Suitability of reference:**
The statement is consistent with other sources, i.e. (DCCEEW, 2021).

*But a small reduction in water flow (by 3 m3/second) would increase the probability of 'cease-to-flow' years (which do not occur under natural conditions) and potentially lead to substantial depletion of the local population [159].*

Reference 159 supports this statement

**Suitability of reference:**
While the reference supports this statement, the main source is Georges et al. (2003) added to the reference list below.

*Lower water levels would impede their movement between pools [54]. Other threatened species in the Daly potentially at risk from water extraction include the largetooth sawfish (listed by the IUCN as critically endangered) [160,161], the northern river shark (listed as vulnerable) [162] and the speartooth shark (listed as vulnerable) [163].*

Reference 54 supports this claim as does Georges et al (2003). Reference 160, 161, 162 and 163 support that the respective species are listed and are found in the Daly River and lists their potential threats which includes water extraction and impacts to natural flows;

**Suitability of references:**
The references used here as well as other references also support the statements made here. e.g., Department of the Environment (2014) and DSEWPaC (2012).

*These risks have not been assessed, but recent research in the Fitzroy River in the Kimberley found 'a clear relationship between wet season volume and recruitment success' for freshwater sawfish, with substantial recruitment only recorded in 3 of 17 years, corresponding to the highest flow years [164].*

This is almost a direct quote from Reference 164 and goes on to say that recruitment only occurred when river stage height spent at least 14 days above the 98th percentile of stage height.

**Suitability of reference:**
The relationship between flow and recruitment is well documented. A/Prof David Morgan of Murdoch University is the WA expert of sawfish where this information can be found in his publications.

*Riparian habitats: Groundwater is essential to maintain riparian vegetation during the dry season – it may account for more than 50% of the water transpired by riparian trees in the dry – and a reduction in groundwater levels below the tree root zone would likely change the composition of riparian habitats [165,166].*

Supported - The first part of the statement ('- it may account...in the dry - ') is a direct quote from Reference 165. The second part is a direct quote from reference 166.

**Suitability of references:**
The first part of this statement is also documented elsewhere, e.g., O'Grady et al. (2006).

*Maintaining healthy riparian vegetation is essential for protecting water quality, for it filters surface and subsurface flows, regulates water temperature (through shading), prevents turbidity and maintains bank stability [167].*

Reference 167 supports this statement as do many other citations in the scientific literature including Askey-Dorin et al. (1999).

*Stygofaunal communities: Animals such as crustaceans, beetles, worms and snails (and occasionally fish) often inhabit groundwater – and the NT is known to have a diverse range of stygofauna – but they have not been surveyed in the Daly River region [169]. Stygofauna typically have small ranges and are therefore likely to be highly vulnerable to loss of habitat through groundwater extraction.*

Reference 169 supports this statement.

**Suitability of reference:**
A peer-reviewed journal article, Oberprieler et al. (2021) based on the work described in Reference 169, has been added below. A further point made by both 169 and the journal article is that the genetic homogeneity of the populations of the large blind shrimp, Parisia unguis, across the Tindall Limestone aquifer indicates that the aquifer is highly connected. This means that the risk of contamination of a well in one part of the aquifer reaching other parts of the aquifer is high.

*Flood waters are also very important in maintaining the rivers of the Daly Basin and floodplain ecosystems. A growing body of research indicates that peak floods play a vital role in sustaining fish breeding and longterm groundwater recharge cycles [6,9,115,170,171].*

These references support this statement. See earlier comments on Impacts on Fisheries.

*Swift-flowing water is likely to support unique ecological communities water [108].*

Supported. This is an almost verbatim statement from Reference 108.

*An unusual insect, the sea skater Halobates acherontis, known from just one location 112 km from the mouth of the Daly, 'seems to prefer fast flowing areas' and therefore may be threatened by excessive water extraction [172]*

This statement is supported, and includes a quote, from Reference 172.

*The Daly River also has an important marine influence, with its discharge into the Timor Sea the second highest of any Australian river [168].*

This statement is supported and is almost a direct quote from Reference 168.

*Unimpeded movements between freshwater and estuarine habitats and between different freshwater parts of the river are critical for maintaining healthy fish populations [9,65,170,171].*

These references support this statement. See earlier comments on Impacts on Fisheries.

## Review of Values at risk in the Daly River Region – Indigenous values

*The Daly River Basin is a living cultural landscape, with around 12 Indigenous language groups having ongoing connections to the catchment [173].*

This statement is supported by the reference which is a report published by CSIRO. Considering the Daly River Basin as a cultural landscape for Indigenous language groups residing in the area in fact aligns well with such values expressed by the Indigenous peoples elsewhere in Australia and globally.

**Suitability of reference:**
A recent report by Jarvis et al. (2022) also highlights such values.

*Water is of central importance in Indigenous cosmology and belief systems [174] and many sites of great cultural significance are connected to water – rivers, creeks, gorges, waterfalls, waterholes, springs, billabongs, wetlands and floodplains [174].*

This statement is also supported by the Reference (174) of the same author as 173, published by an Indigenous organisation (NAILSMA).

*Traditional Owners have customary obligations to keep the water clean, protect access to particular places along the river, maintain and pass on cultural knowledge, and share songs and stories involving the river [68]*

Customary obligations are the duties and responsibilities that Indigenous peoples in Australia carry and maintain in relation to their clan area. This is a generic statement.

**Suitability of reference:**
However, the cited Reference 68 only mentions important social and cultural sites and the cited reference within Reference 68, i.e., McJannet et al. (2009), Reference 173 and 174, cited earlier, also support this view.

*These cultural values depend on maintaining a healthy river, including the linkages between the river and land, floodplains and aquifers [175].*

The above statement is mentioned a bit broadly in the source [175], referring to the environmental, cultural, recreational and agricultural uses and values.

*Our culture is really important to us. Our culture sits in the river system… We believe the river provides for us properly, and for birds and animals. If something did happen, it's our life: it provides bush tucker for us traditional owners.*

*[presumably, the following text is a reference to the quote above:] Marranangu representative on the Daly River Aboriginal Reference Group [173]*

This statement is a verbatim from the cited reference 173. No discrepancies.

*Maintaining the health of the Daly is also essential for the provision of safe drinking water to Indigenous communities and to sustain fishing, as well as the harvest of foods, fibres and medicines. The most commonly caught and harvested species in the Daly River are barramundi, sooty grunter (black bream), long-necked turtle, lotus lily, magpie goose and shortnecked turtle [176].*

**Suitability of reference:**
Not all the items listed in the statement are mentioned in the cited Reference 176. For example, turtles or lotus lily are not mentioned in the cited document. Additional references are required to more fully justify these statements.

*The river is also central to a growing cultural tourism industry [144].*

This is fair general comment as cultural tourism in the north depends on the health of the rivers, and well supported by the reference 144 (published by WWF Australia).

*The creation of Aboriginal water reserves is a relatively recent addition to the NT water planning framework – as part of government efforts to create economic opportunities for Aboriginal people. Under this system, a proportion of water is to be reserved for economic use by Aboriginal landholders, proportionate to their landholdings. However, this policy is far from being realised in practice and is an economic incentive not designed to deal with cultural, ecological or social impacts. [paragraph presented without references]*

This statement is at the end of the section, suggesting the authors are outlining solutions and related policy issues.

**Suitability of reference:**
These views are, well supported by the NT Government Strategic Aboriginal Water Reserve Policy Framework (2017).

*Only recently have there been efforts to more fully incorporate Indigenous people's knowledge of and interests in rivers into environmental research and economic activities [173].*

A fair comment. This is supported by the Reference 173

*Water resource developments have typically neglected the social, cultural and economic impacts on Indigenous communities, and contemporary management processes still do not adequately involve Indigenous people in decisions fundamentally impacting their lives and cultures [173].*

Yes, this statement is supported by the Reference 173. Given that the development of water policy is relatively new in the NT, there is a general perception for appropriately addressing the social, cultural and economic impacts on Indigenous communities.

*[repeated sentences]*
*The creation of Aboriginal water reserves is a relatively recent addition to the NT water planning framework – as part of government efforts to create economic opportunities for Aboriginal people. Under this system, a proportion of water is to be reserved for economic use by Aboriginal landholders, proportionate to their landholdings. However, this policy is far from being realised in practice.*

As mentioned above, this text is towards the end of the section where it seems that authors have outlined the way forward for suggesting implementing the idea of Aboriginal water reserves.

*In the Daly catchment, these water reserves are only partially provisioned or not provisioned at all (due to overallocation of aquifers) or have not been created because there is no water allocation plan (see Table 4 for their status).*

This text summarises the practical issues around establishing Aboriginal water reserves, the information is interpreted from Box1 and Tables 2 and 3 (not 4), each with several sources mentioned in the box as well as footnote under the tables.

**Suitability of reference:**
The partial provision is further discussed in the meeting notes of the 2019 Tindall-Mataranka to Daly Waters Water Advisory committee (NT Government, 2019).

## Review of Values at risk in the Daly River Region – Economic values

*A substantial cotton industry in the Daly River Basin is likely to compromise economic activities that rely on river and catchment health, and potentially reduce water security for existing irrigators [144].*

The cited Reference 144 does mention the risk of excessive water extractions (to the volume of 125,000 ML for new applications) stating, “Issuing licences for this volume of water would see extractions increase at least sevenfold in the Daly. This would significantly risk the Daly River’s health, jeopardise environmental flows, and potentially reduce water security for existing irrigators”.

**Suitability of reference:**
The point if the cotton industry in the Daly region relying on river/catchment health is valid. These points are noted in some industry reports, i.e., Reference 2.

*Nature-based tourism is a leading industry in the area. In the Big Rivers Region, which encompasses the Daly and Roper river regions, tourism contributed $156 million to the economy in 2017–18 and employed about 10% of the working population [177].*

Yes, this report published collectively by the NT Government and other partners clearly highlights the economic potential of the Big Rivers Region on 6 of the cited Reference 177.

*In 2019–20, tourism and hospitality sales in the Litchfield Council area alone generated $74 million in spending, and the total value added was $35 million [178].*

Yes, supported by the Reference 178 that is available online (https://economy.id.com.au/rda-northern-territory/tourism-value).

*Eleven tourist parks and 7 guided fishing tours operate on the lower Daly [179]. The tourism appeal of the Daly River region is largely focused on nature-based experiences (parks, rivers, fishing, hot springs) and cultural experiences [180].*

The second part of statement is supported the reference 180 while the first is personal communication.

**Suitability of references:**
Given the statements made, the use of the reference is reasonable.

*The Daly arguably offers some of the best fishing in northern Australia [181].*

Clearly the Daly River is widely used by recreational fishers. Whether or not the Daly provides the best fishing in northern Australia is inconsequential to the Report.
This is well supported by the cited document (181), published by the Department of Infrastructure, Planning and Environment, NT.

*Recreational fishing is a major activity for both locals and tourists and a primary economic driver [182]*

Yes, supported by the cited Reference 182, published by the NTG.

*Fishing contributes an estimated $26 million/year, about 80% from interstate or overseas visitors [183].*

These are the correct figures from the cited source describing fishing tourism contributes about $26M/yr, with $22M/yr contributions from interstate or international visitors.

**Suitability of reference:**
Data are from the NT Government. Further information about fishing and the economy is available in West et al. (2012), amongst other sources.

*It offers development opportunities for remote Indigenous communities [183].*

Yes, the statement is supported by the cited Reference 183.

*Annual fish competitions such as the Barra Nationals, Barra Classic and the Million Dollar Fish generate significant investment in the region (and Darwin). The Barra Nationals generate over a million dollars in entry fees, and significant flow-on benefits to the regional economy and local communities [144].*

This statement is consistent with the earlier reports and supported by the cited Reference 144.

**Suitability of reference:**
The importance of fishing for economic and tourism purposes is mentioned by several authors cited earlier (References 181-183).

*River-centred cultural industries – art and cultural tourism – are important and growing sources of income for Aboriginal people. The Nauiyu Nambiyu Community Council and Merrepen Arts, near the Daly River, bring in millions of dollars of income [144].*

It is well known fact that Indigenous art and cultural tourism are the main industries operating across the NT. Yes, the statement is supported by the cited Reference 144, page 15.

## Summary of evidence base of the major points made in the Report

With significant interest in developing northern Australia from Commonwealth and State/Territory governments, there will be an increased focus on water allocation and land use change/ land clearing in coming years. The Report provides an overview of potential impacts of the proposed expansion of the cotton industry in the Northern Territory. The scope of the Report is broad, covering projections of the growth of the cotton industry, environmental constraints and impacts, and the values that are at risk in the Daly region.

The Report provides a large amount of information based on a review of a substantial body of literature that includes peer-reviewed scientific papers, technical reports (including NT Government, Australian Government and CSIRO-led reports) and media articles. Through this Review, a broad range of references that either provide further clarification for statements, or present other views were also collated.

The (original) referenced literature from the Report were used to produce six recommendations, i.e., to:

(1) Place a moratorium on new water licences in the Daly and Roper River catchments,
(2) Protect ecological processes, prohibiting large-scale extraction of flood waters,
(3) Acknowledge knowledge gaps and utilise the precautionary principle in decisions, particularly with respect to flood water harvesting and land clearing,
(4) Adopt an integrated catchment planning approach,
(5) Enact reforms to prioritise the public interest and increase public trust in decision making, and
(6) Ensure that environmental impact assessment processes fully address cumulative impacts of proposed developments.

The Report discussed the potential impacts of the projected expansion of the cotton industry in the Northern Territory, using widely available projections of cropping areas and an 80/20 split of dryland and irrigated cotton as reported in industry projections. In the case of the Cotton Industry Growth Projections section, calculations presented in the Report were assessed against the data available in the reports provided. These values were generally supported by the projections available across the references from the Report, however further details on the calculations are presented below.

Our review assessed 211 statements from the Report that included references or inferred them from adjacent sections of text. Our view is that the majority of the Report was supported by the references used. However, we identified multiple instances where the Report omitted some detail that would have provided further context for the reader to understand the referenced material, cases where values could not be fully verified from the original reference, and cases where we could not locate the material in the references provided. Some issues with the Report that were identified through the Review include (although we note that whether or not statements fit under the categories below is subjective):

- Instances where the Report could have utilised a broader range of literature to strengthen the validity of the statements made, or used more reliable references (e.g., a peer-reviewed article in the place of a news article, private meeting notes, or a website from an Environmental organisation). We have included additional references that support or

provide clarification of the information presented in these cases, where relevant. Statements in this category were observed on 22 occasions.

- We document where the interpretation of the references tended towards the greater potential consequences. These included instances of rounding up in calculations, selecting the upper range of values (e.g. “up to about 200,000 ha”), where value judgements have been made by the authors beyond what was included in the referenced statement, and/or use of values that were difficult to verify from the references provided. Statements in this category were observed on 17 occasions.
- Instances were identified where the statements in the Report were not supported by the reference used, or where the incorrect reference appears to have been used. These included instances where quotes could not be identified, as well as cases where the original references appear to have been misinterpreted and/or misunderstood. Statements in this category were observed on nine occasions.

The statements that drew on scientific evidence relating to potential environmental impacts were generally supported by the citations provided and, where relevant, consistent with the broader literature. The Report also makes a number of statements about the adequacy of the policy and regulatory framework for environmental protection in the context of cotton industry development. The Review commented on these statements, but we note that broader discussions about policy or regulatory frameworks relating to water resources are available elsewhere (e.g., Hart et al., 2020; Currell and Ndehedehe, 2022).

Decisions concerning the development of Northern Australia have important economic and environmental implications for the Northern Territory in future years. It is our view is that it is vital that the best available data/information be utilised in the decision-making process. In cases where insufficient data/information are available, that the appropriate investigations are conducted in an open and transparent way to support the decision-making process.

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