



Review of ecological impact of current unconventional gas operations in the Surat Basin, Queensland

Submission to the Australian Tribunal into the Human Rights Impacts of Unconventional Gas (Session 3 – Environment and Climate Change)

Ethical Ecology
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Declaration of Accuracy

To the of my knowledge all information contained in this document are current and accurate.

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1. SUMMARY

The last decade has seen a rapid expansion of the onshore unconventional gas industry in Queensland, particularly the Surat basin, though gas development has also proceeded in the northern Bowen Basin, the Surat Basin was chosen for this review because of the longer history and greater extent of operations. There have been four primary large gas development projects, each with its own onshore gas field, processing plants and pipelines, GLNG (Santos), QCLNG (Shell), APLNG (Origin Energy/ConocoPhillips) and Arrow Energy. Cumulatively the industry has established tenements over 2.6 million hectares in the Basin.

Impact of gasfield on ecosystems and habitats are generally considered to be 'low' and manageable by proponents mainly because of small scale of direct impact at a regional scale. But there are a number of key issues which has plagued the approval of the projects. Together they have reduced the reliability of the assessment of impact on the natural environment of the unconventional gas industry:

1. Significant question marks remain over the transparency of the consent process used to kick-start this industry in Queensland;
2. Little account at all taken of indirect impacts in approvals and cumulative impacts;
3. Low level of reliability of surveys to accurately map and determine presence or absence of sensitive matters;
4. Poor analysis of the impact on groundwater resources and consideration of impacts on groundwater ecosystems;
5. Poor consideration of impacts upon surface waters;
6. Poor consideration of impacts of Gladstone development on marine environment and World Heritage Area,
7. Inadequacy of offset proposal and management plans to compensate for impacts.

These issues have hindered the generation of a baseline level of ecological data as an accurate reflection of what is present and being impacted on the ground and therefore an accurate picture of the impact. This is as much an issue for government who have compounded this by allowing the approvals to proceed without the usual requirements being met prior to approval. The Commonwealth and Queensland Governments have subsequently attempted to make companies accountable in some of the matters of concern through consent conditions and management strategies. However, besides a lack of baseline data, the scientific validity of this process is further hindered due to the time-lag between initial consent and finalisation of the plans - allowing construction to proceed without oversight.

The Queensland Government's Co-ordinator General's reports on these projects indicated that at the time approvals were given that additional information was sought from all three initial projects regarding cumulative impacts, regional groundwater modelling, coal seam gas water management plans, brine management strategy, ecological constraints management strategies including offset plans. These requirements are still being finalised in some instances.

Given these considerations, in the ten years during the development of the unconventional gas industry in the Basin, several environmental issues have surfaced that also bring into question the ability of the industry to mitigate impacts as well as the veracity of currently used operational procedures. Notably, the extent of habitat fragmentation and loss, the impact of fracking and well integrity on aquifers and the disposal of by-product water on aquatic systems are becoming better understood as time progresses. These can have long-term implications for the resilience of ecosystems at a regional scale and the people that inhabit these areas.

Poor consideration of baseline, indirect and cumulative impacts of the industry also makes it extremely difficult to audit the environmental performance of the onshore unconventional gas industry. This report has attempted to put the extent of on-ground impacts of the industry into perspective and to highlight current gaps in our understanding.

2. IMPACT SYNOPSIS

Impacts from onshore unconventional gas development at the scale given approval in Queensland are wide ranging, both direct and indirect, in a wide variety of landscapes and geographies. They can be grouped as:

Gasfield and associated infrastructure.

These consist of direct impacts from the establishment of gas wells and sites, processing and treatment plants, storage ponds and a network of gas and water transmission lines, tracks and roads. Use of chemicals and drilling techniques, (particularly ‘fracking’ and directional drilling) and construction and production activities have a range of impacts on terrestrial, surface water and groundwater environments.

Pipeline and bridge infrastructure.

The main transmission lines of gas from the production fields to the port at Gladstone and potential impacts on marine, terrestrial and surface water environments. Particular hotspots are the inland river crossings and at the Narrows in Gladstone Harbour.

Gladstone Port development

LNG development in the harbour area is considerable and includes processing plants, loading facilities, storage, sediment dumping areas, swing basin and access channels. These activities will affect both terrestrial areas on the mainland and Curtis Island as well as the marine environment in the area.

2.1 Timeline of Unconventional Gas Development

The following account considers approvals granted by the Commonwealth only, as Commonwealth approval is generally the last hurdle for development to proceed in Australia.

Gladstone LNG Project (Santos)

State and Commonwealth approvals were granted in 2010, with an expansion of the gasfield area approved in 2016. Conditions placed on 2016 expansion includes staging of the impact assessments.

Santos GLNG Project’s gas fields initially were authorised for 2,650 production wells but was increased in 2016 to 8,750 wells, covering an area of 988,500 ha under the Gas Field Development Project (GFDP).

Pipelines will cover 435 km and cross streams, including the Dawson River of the Fitzroy River Catchment and coastal estuaries, though amount of gasfield transmission lines, tracks etc is not known.

Australian Pacific LNG Project (Origin Energy/ Conoco/Phillips)

Initial EIS and referral were approved in 2011 though there have been several variations since then. An extension of the gasfield was approved in 2014. The Walloons Gas Field covers an area of 370,000 hectares supporting up to 10,000 wells. APLNG plans more gasfield extensions, with three or referrals in 2016/17. If approved these projects will cover a further 45,000 ha and 220 more wells.

Main pipelines will cover 450 km and cross streams, though amount of gasfield transmission lines, tracks etc is not known.

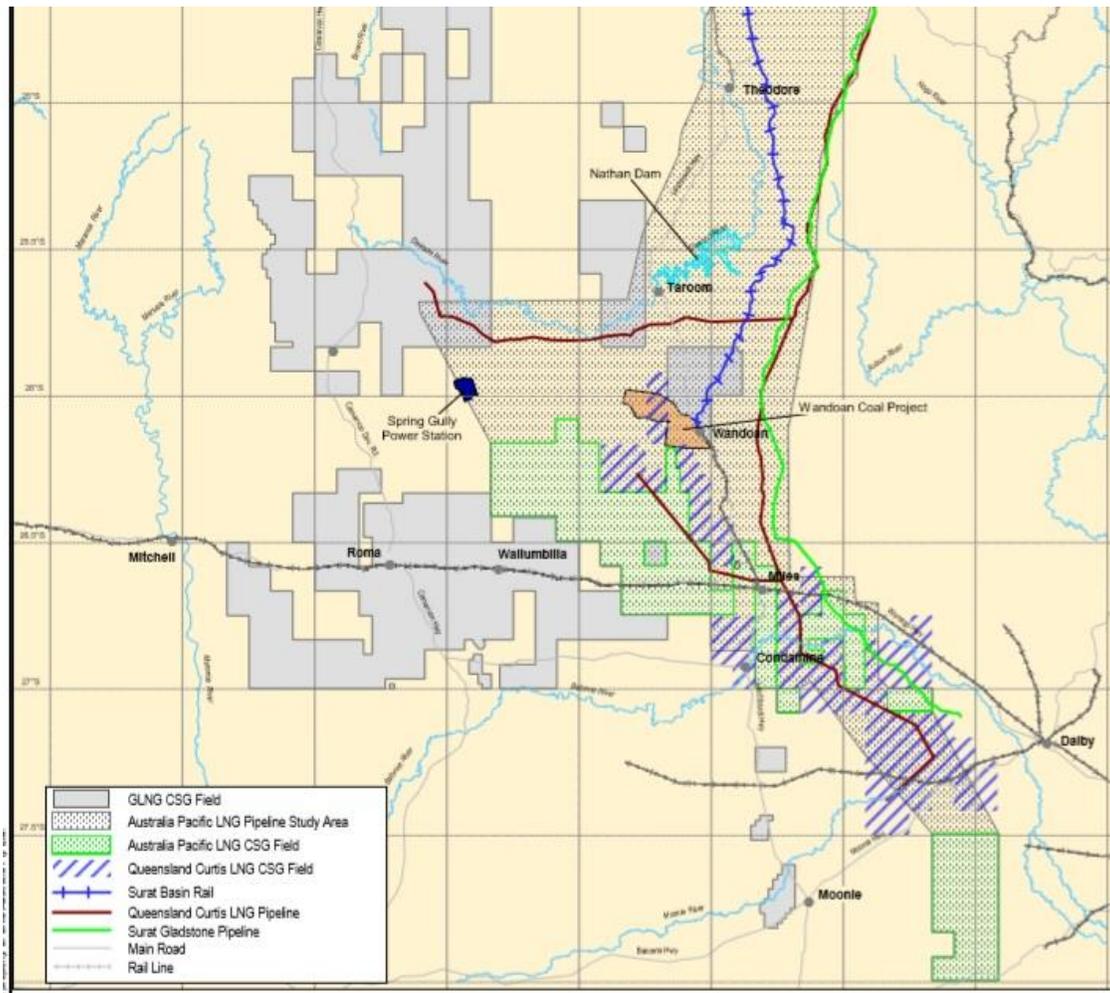


Figure 1. Extent of gasfield tenements in Surat Basin

Queensland Curtis LNG Project (Shell)

Initial State and Commonwealth approvals were granted in 2010, with two subsequent extension of gasfield acreage in 2014 and in 2017 for an additional 600 wells. In 2014 a condition was made requiring QCLNG to report non-compliance. QCLNG tenements cover some 450,000 ha, this project will support 6,000 gas wells over life of project covering 26,000 ha with direct impacts expected over 7,000 ha, additional to 2000 ha of existing infrastructure.

Main pipelines will cover 730 km and cross streams, including the Dawson River of the Fitzroy River Catchment and coastal estuaries, though amount of gasfield transmission lines, tracks etc is not known.

Arrow Energy

Arrow/s gasfield facilities were given a consolidated Commonwealth approval in 2013, including a processing plant and 1,800 wells.

This company also obtained an approval in 2013 for a facility on Curtis Island. This was given a 530 ha disturbance limit by the Commonwealth as well as a transmission line to cross Port Curtis, but based on the latest information neither of these projects has yet proceeded.

2.2 Extent of Direct Impacts

The cumulative extent of unconventional gas development in Queensland is presented below. Tenements cover an area of over 2 million hectares. For the gasfields, developments are undertaken in stages, for example for the GLNG project their initial development of 2,650 wells covered a project area of 6,887km² (0.4 wells/km²) while the expansion of the field by 3,800km² will support an additional 6,800 wells a much greater density at 0.7 wells/km².

Gas well sites generally cover an area of about one-two hectares, expected well establishment will mean direct impacts on about 26,000 ha of vegetation from the three projects. The area of tracks and connecting transmission lines is not well documented though would at least cover the same area as the well sites themselves and likely to be considerably more. For the main gas transmission line to Gladstone, a Right of Way of 30m is identified in the documentation. The total area to be cleared for these lines amounts to over 4,800 ha.

Table 1. Extent of tenements and impacts of onshore gasfields in the Surat Basin, Qld

	GLNG (ha)	APLNG (ha)	QCLNG (ha)	Arrow (ha)	TOTAL (ha)
Tenements	988,500	370,000	450,000	800,000	2,608,500
Project Area	staged	staged	staged	staged	
Direct Impact (well-sites)	~9,000	~20,000	13,500	1,800	~44,300
Direct impact (gas-line)	1,305	1,350	2,190		4,845

Given the uncertainty around areas cleared for gas field infrastructure other than well sites, the total area directly affected by all gas projects would be in the vicinity of 100,000 ha. The actual amount of native vegetation that require clearing, whether it be listed as threatened or not, is not available within the EIS documentation.

3. INDIRECT IMPACTS

Though it is required by the Commonwealth's policy, no consideration in the consents was undertaken of indirect impacts, in any of the gasfield project impact statements within a spatial context. Offset provisions only count direct areas of impact, which are largely estimates. Impact assessment should have included consideration of increased levels of the following upon ecosystems and species:

- Feral animal and weed infiltration is made easier with increased habitat clearing, particularly through larger vegetation remnants, which may have been inaccessible prior to disturbance (Meek and Saunders 2000). This process is facilitated by increased traffic and human movements in these areas;
- Noise and vibration associated with gas infrastructure can adversely affect both plant and animal life and the carrying out of their essential behaviours (Francis and Barber 2013);
- Dust and air-pollutants can be detrimental to the respiratory systems of plants and animals, including people. The National Toxics Network have previously made submissions on this topic, outlining the range of toxins in emissions produced by this industry, the consequences for natural biota has not been studied adequately. Fine particulate matter, can interfere photosynthesis and plant growth and can act as vectors for the dispersal of toxic compounds (Grantz et al 2003);
- Light pollution associated with gas infrastructure can adversely affect both plant and animal life and the carrying out of their essential behaviours. This is a poorly understood area (Gaston et al 2017);
- Offsite water and soil impacts by the generation and disposal of by-product (“associated”) water and solid waste materials;
- Increased traffic and shipping and their impacts on wildlife;
- Habitat fragmentation will be extensive through gasfield development, networks of cleared lines and sites will increase the edge-effect of air, light and noise pollution and increase weed and feral predator penetration throughout vegetation remnants affected. The scientific literature on this subject is extensive;
- Impacts on harbour ecosystems. While some direct impact to littoral and marine environments were identified, a good proportion of the impacts of the Port development for these projects are impacts on water quality, the marine fauna and flora which use this environment and on benthic health by increased turbidity and movement of toxic elements in the ecosystem;
- Damage to aquifers by fracking and directional drilling can change pathways of aquifer inter-connectivity and cause drops in the water table. Chemicals used with the drilling activities are not completely recovered from groundwater bodies and can add to the toxicity of by-product water.

Subsequent to the approvals being granted, the Commonwealth tried to address some of these issues through a variety of ‘variations’ to the approval conditions, though in most cases not for many years following the commencement of the project.

For example, the variation to APLNG consent in 2016 was aimed to compensate for impacts of the Great Barrier Reef World Heritage Area, states, “*to offset indirect impacts, a contribution of \$200,000 per annum for the life of the project (indexed at CPI) and in addition \$100,000 per annum (indexed at CPI) for each operating LNG Train (commencing upon commissioning of the relevant Train) to be*

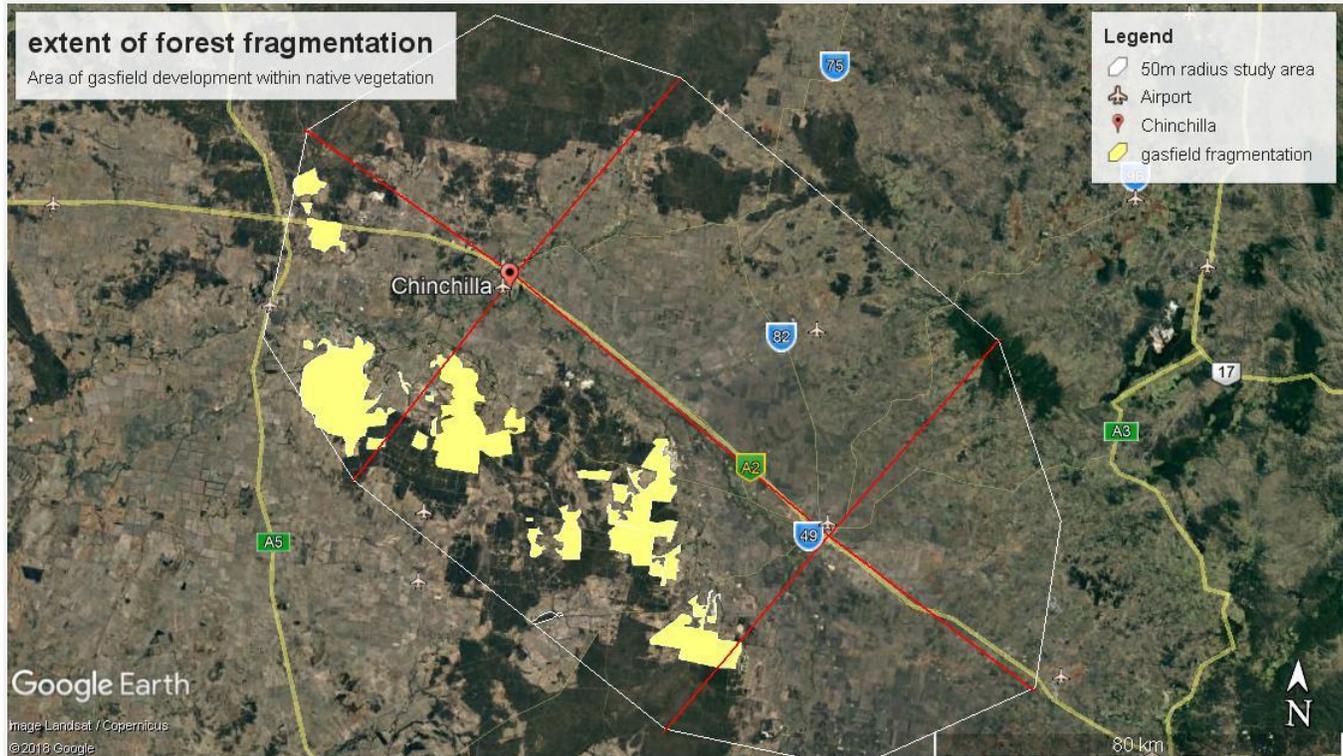
provided to an entity or agency or government authority (such as the Reef Trust) agreed to by the Minister, for expenditure or investment in the Mackay / Capricorn Section on environmental projects to protect and manage the Great Barrier Reef World Heritage Area.”

Another way this was dealt with was to allocate offset areas and in 2014, the Commonwealth conditioned the QCLNG Project a 700ha land offset to compensate for indirect impacts, though how this figure was calculated is not certain. The 2017 consent variation for the APLNG project has added for the first time, consideration of off-site impacts though what this means for the developer is not clear.

“... may be potentially impacted by that stage of gas field development within the project area, or external to the project area.”

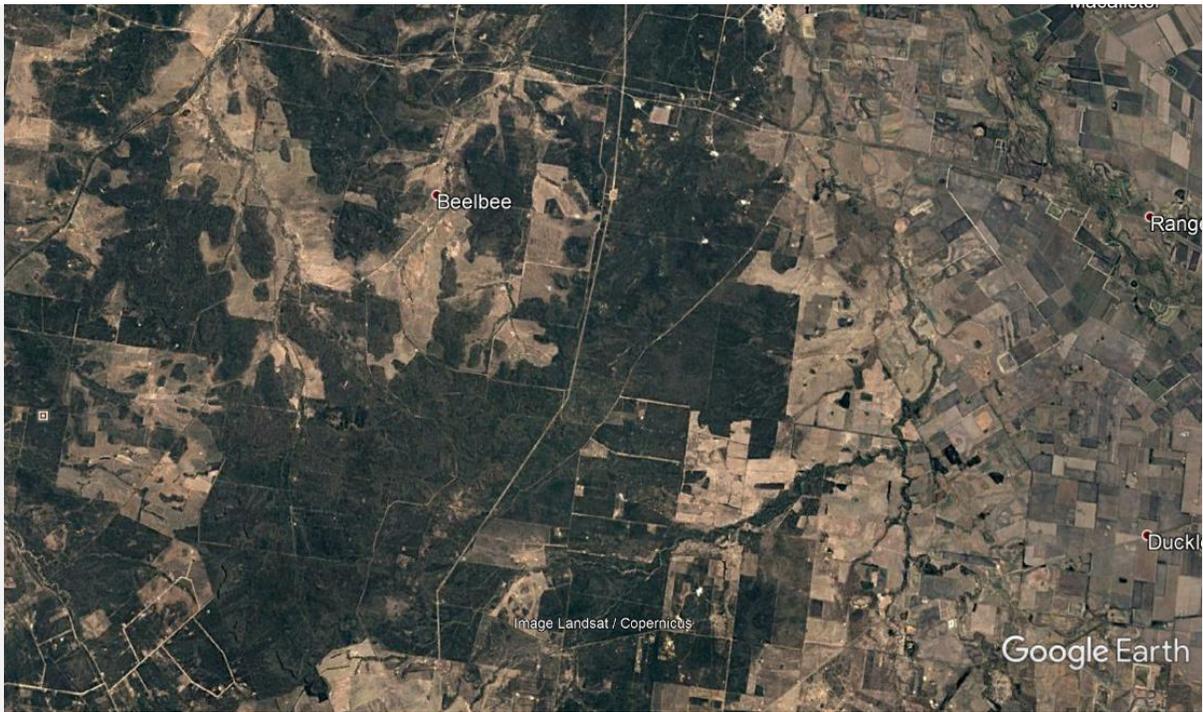
Example 1. Scale of habitat fragmentation

The indirect impacts of habitat fragmentation on the environment at a regional scale, though largely unquantified, can be considerable. For example, the actual scale of habitat fragmentation in existing remnant vegetation can be seen clearly from the Chinchilla/Dalby area.

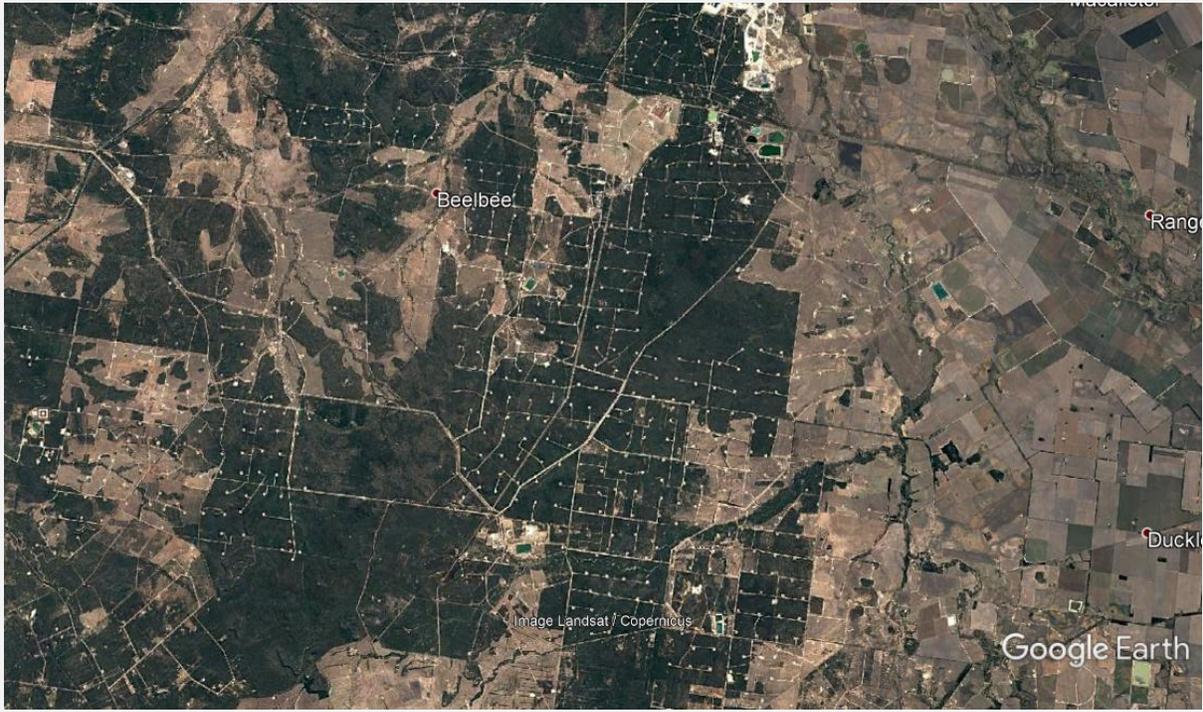


Extent of forest fragmentation from unconventional gas development at a regional scale

Approximately 900 km² (90 000 ha) of remnant vegetation in this area is fragmented by unconventional gas development by a grid-work of wells, pipelines and connecting roads. The affected area amounts to about 25% of all remnant vegetation within 50 km of the two towns. More large-scale gas developments in this area are planned.



Remnant vegetation near Dalby prior to unconventional gas, Qld, 2002.



Area of Arrow Energy's gasfield 2017 showing intensity of gasfield development

Example 2. Disposal of associated water

A key issue for the health of surface ecosystems and waterways as a result of unconventional gas activity is how 'produced' or 'associated' water and toxic drilling residues are stored and disposed of. The GLNG project alone which allows for 2,500 gas production wells will produce 80ML of produced water per day (Santos 2009). Gasfield expansion by Santos could see this amount reach 200ML/day. QCLNG Project has a peak of 180ML/day.

Analysis of this by-product has shown a toxic mixture of hydro-carbons, salts, metals and NORMs (National Toxic Network 2013). At the time of the project approvals, there was poor oversight of the management of this by-product into the environment. For the QCLNG Project for example, requirements to treat associated water prior to release into specified transmission lines and the preparation of CSG Water Monitoring and Management Plan were not specified by the Commonwealth until 2012.

Despite companies claiming that impacts on surface water will be low, a review of disposal and end uses of associated water shows:

- Much is 'treated' in osmosis plants and re-used for domestic, municipal and agricultural water users;
- Concentrated brine is stored in above ground-containers or used in land-fill and subject to leakage and groundwater contamination;
- Raw by-product water is often held in dams and allowed to evaporate;
- Much is sprayed onto roads as 'dust suppression', finding its way into waterways and water tables;
- 'Treated' or 'de-salinated' produced water is dis-charged into natural waterways. These treatments do not remove all toxic components of associated water.



Produced Waste Water used for Dust Suppression

However, restrictions on discharge into natural and man-made waterways has eased with a variation to Santos' consent in 2016 which allows the Qld Minister to approve discharge of associated water into waterways, if it is not thought to have significant impact on Commonwealth sensitive matters.

4. GROUNDWATER

The Qld Government's C-G Reports noted the failure of the proponents to address impacts upon groundwater and groundwater dependent ecosystems. The use of both wells, 'fracking' and directional drilling technologies have the potential to damage aquifer integrity, changing avenues and rates of inter-aquifer exchange of fluids and introducing a wide range of chemicals with the potential to contaminate groundwater. Despite the failure in the provision of data to substantiate modelled outcomes, approval was given to the projects at both levels of government. Companies stated that there would be no significant impact on non-target aquifers and no cumulative impact because of the separation between projects.

4.1 Shortcomings of groundwater assessments

A cumulative impact assessment of CSG on groundwater resources in the Surat Basin was finally published in 2012 (Qld Water Commission). It predicted that while 528 bores will experience water level decline that will exceed the trigger threshold in the long-term, but overall leakage of water from the Condamine Alluvium will be less than the trigger threshold of 2 metres. The Qld Government determined there is a 'No Immediately or Long-term Affected Area' for the Condamine Alluvium.

However, following a requirement by the Commonwealth to comply with 'water trigger' laws, in 2014, the Commonwealth's Independent Scientific Committee noted that for the expanded GLNG project, all documentation concerning the impacts of CSG on the Basin were inadequate for determining magnitude of impact:

1. The hydro-ecological information, including ecological water requirements of systems, provided was inadequate for understanding potential ecological impacts at the local scale. Groundwater baseline information in some areas was limited.
2. The methods used for understanding local-scale impacts are not sufficient, particularly to ecological assets. This results in a high level of scientific uncertainty associated with the local scale impacts and the mitigation of those impacts, particularly with respect to springs.
3. The proponent has undertaken a significance assessment of sensitive habitats and magnitude of impacts, with no consideration of the likelihood of the hazard occurring.
4. Potential reduction in baseflow to surface waters and springs due to groundwater drawdown is not estimated.
5. Local scale conceptual models for surface water resources and ecological values, including relationships between baseflow, groundwater drawdown, faults and springs was not provided

These issues have not been addressed. In 2017, the Alfredson Block expansion for the APLNG gasfields also was heavily criticised for requiring better site-specific hydrogeological data, needing improved numerical groundwater modelling which could then be used to support the consideration of cumulative groundwater impacts; the lack of chemical assessments, and lack of plans to manage the long-term storage of salt to '*give confidence that management is feasible and low risk*'.

However, there is increasing evidence that gasfield activities have caused significant damage to local aquifers with reports of significant gas seepage and dropping water tables, particularly in the Condamine area.

There have been widespread reports of bores running dry and gassing up going back to 2012 following the rapid development of coal seam gas in the Condamine area (see Department of Natural Resources and Mines report 2012). In a submission in 2014 to the Queensland Government, the Basin Sustainability Alliance stated that there were fears that bores could no longer be drilled in the Cecil Plains. www.abc.net.au/news/rural/2014-07-30/country-hour-goes-to-cecil-plains/5635600

Example 3: Surface gas seepage

Despite the assertions of companies that their activities are 'low risk', unintended damage to aquifer integrity as a result of fracking and drilling can result in changes to the hydraulic movements of water and gas under the ground, increasing chances of contamination from coal-bearing seams and aquifer depressurisation resulting in lowered water-tables. Examples of both effects are apparent in the Condamine area.

The phenomenon of the bubbling of methane in the Condamine River, started in 2012 following gasfield development in the area, intensified in 2016, and despite claims of it being 'natural', the link between unconventional gas development and the methane seepage has recently been confirmed by Melbourne Environment Institute <http://au.pressfrom.com/news/australia/-18035-csg-could-increase-methane-emissions-near-bubbling-condamine-river-report-finds/>

Origin have been left to address issue in an unrestricted way. This has led to the construction of a number of wells designed to intercept the gas flow under the river. Origin claim this has led to a reduction of gas seepage in the river, though seems to have opened up more pathways to facilitate drops in river levels if gas migration slows. <https://www.dalbyherald.com.au/news/river-bubbles-burst/3302754/>

Other studies by Queensland University has shown gas seepage through the ground to be extensive in the gas fields compared to background levels. But, research into impacts of unconventional gas impacts in Australia are now being guided by CSIRO's research group GISERA who are an industry funded body. They looked at 37 well heads in Qld and found nearly all gave off fugitive emissions. The original QU research has been shelved.



Condamine River methane releases worsened after development of unconventional gas.

4.2 Groundwater dependent ecosystems

Impacts on groundwater availability affects not only landowners but also natural ecosystems which can be reliant on this resource.

All LNG developers took pains to point out that impacts on groundwater ecosystems was thought to be inconsequential, but these part of the assessments generally failed to adequately consider the magnitude of potential impacts of aquifer depressurisation and also the nature and location of potentially affected groundwater ecosystems themselves.

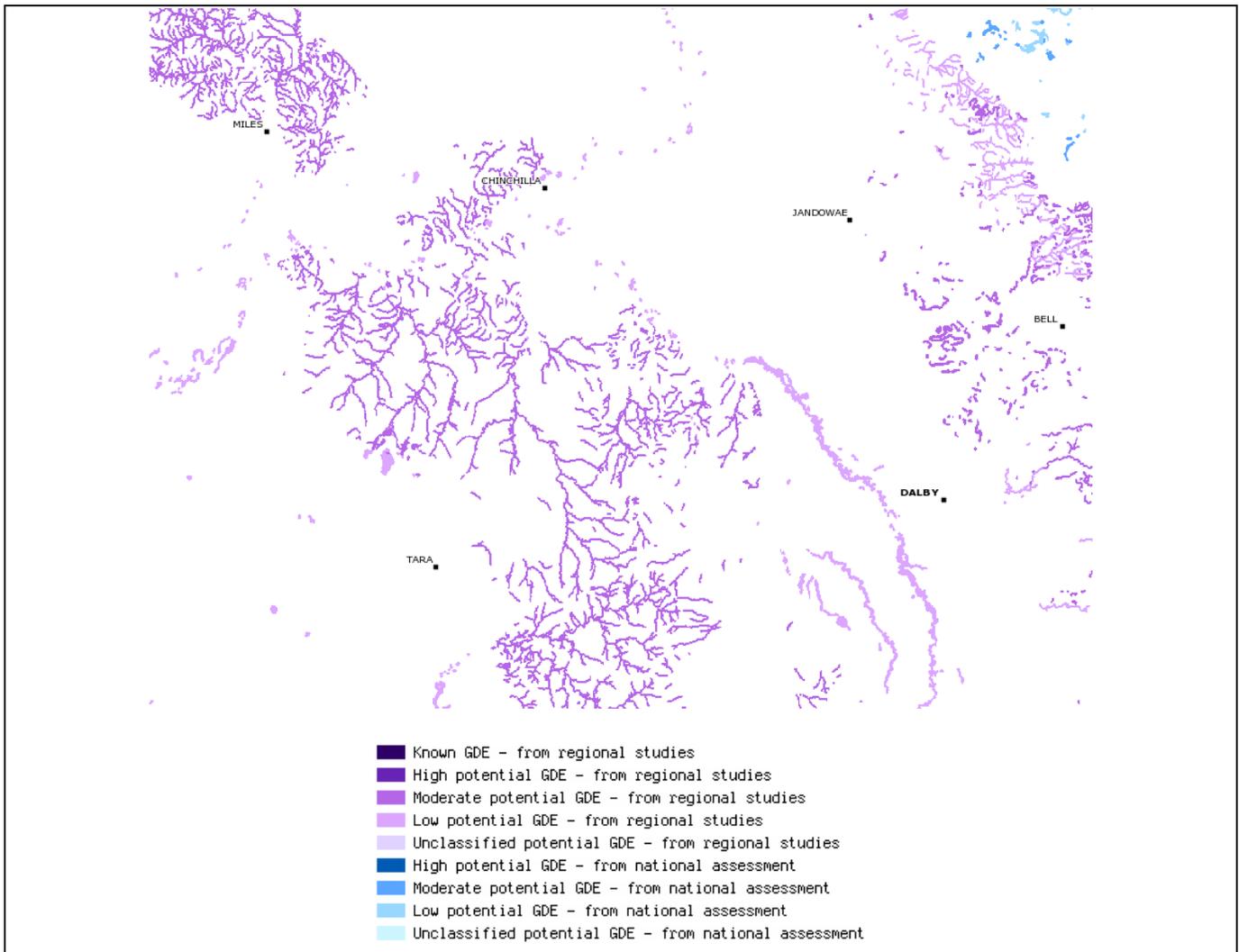


Figure 2. Aquatic Groundwater Dependent Ecosystems in the Condamine area

While Queensland legislation required the proponents to consider certain mound springs, groundwater dependent ecosystems are generally much more diffuse in nature over large areas of the landscape. This can be seen in the figure above derived from the Bureau of Meteorology's Groundwater Dependent Ecosystem Atlas. Most are associated with streams and wetlands which are to some degree, dependent on surface interaction of groundwater. These aquifer systems not only support terrestrial vegetation but also subterranean biota, such as stygofauna. None of these components was considered by any the proponents.

5. CUMULATIVE IMPACTS

Despite the poor way this issue was addressed in the individual EISs, the Co-ordinator-General's Report for the GNLG Project in 2010 undertook a cumulative assessment of the three LNG Projects. No account was taken of other mining projects in the bioregion.

Based on the data provided by the proponents, the report identified a number of magnitudes of impact risk in their assessment. The table below is based on these findings and provides an overall cumulative assessment. This assessment does not take into account subsequent gasfield expansion, particularly for Santos' Gas Field Development Project, values for magnitude of risk are likely to be higher than presented below.

Table 2. Cumulative Impact Assessment Onshore gas development in Surat Basin, Queensland

	GLNG	QCLNG	APLNG	Arrow	Cumulative
Gasfield					
Terrestrial ecology	Low	Moderate	Moderate		Medium
Aquatic ecology	Medium	Moderate	Moderate		Medium
Surface water	Low	Minor	Moderate		Low
Groundwater	Medium	Moderate	High		High
Pipeline					
Terrestrial ecology	Medium	Negligible	Moderate		Medium
Aquatic ecology	Low	Minor	Low		Low
Marine ecology	High	Significant	Low		High
Surface water	Low	Negligible	Low		Low
Groundwater	Low	Negligible	NA		Low
Gladstone harbour					
Terrestrial ecology	Medium	Moderate	Moderate		Medium
Aquatic ecology	Low	NA	Low		Low
Marine ecology	High	Significant	High		High
Surface water	NA	NA	Low		Low
Groundwater	NA	NA	NA		

High or significant cumulative impacts were predicted by the Qld Government for impacts on groundwater by gasfield operations and on marine ecology by construction of the pipeline and the LNG plants and harbour facilities.

Medium impacts may be significant for a particular species/communities at particular locations.

The Co-ordinator-General's Reports stated that no LNG gas field development overlaps the other, reducing cumulative impact. But this by itself is irrelevant to cumulative impact, rather should rather be considered as additive, a combined impact across bioregions and ecosystems. For threatened species it was contended by proponents that no threatened species occurred across all gas field areas, though based on publicly available evidence this is certainly not correct.

For the most part, a proper impact assessment of the gasfield developments was not possible due to insufficient information provided on the location of infrastructure in the EIS, making accurate cumulative assessments difficult.

"Taking into account the lack of suitable presentation of field development plans, I cannot be certain of the extent of disturbance which the project will have on each class of biodiversity status." (C-G report of GLNG Project, Ch.6.4.5)

6. GLADSTONE HARBOUR

Impacts on marine ecology as a result of development in Gladstone harbour are stated by all proponents to be potentially 'high'. This to a large degree, reflects the inclusion of the Western Basin Dredging proposal in the proponents' assessments. Substantial risks were also due to the mobilisation of acid-sulphate soils, through pipe construction linking the mainland to Curtis Island and through excavation activities associated with the shore facilities.

However, to minimise impact, it was determined by the Qld Government that the dredging for each of the proponent's channels, swing basins and berths should be undertaken as a single project under the control of the Gladstone Port Corporation who would manage marine impacts and responses. Rather than reduce the extent of impact though, this proposal aims to stage the activities to reduce intensity.

At stake are impacts upon the Great Barrier Reef Marine Park on the eastern side of Curtis Island and the Great Barrier Reef Coast Marine Park, 'The Narrows'. Port Curtis, south of the entrance to 'The Narrows' is listed in the Directory of Important Wetlands in Australia. It has been identified for its extensive range of marine wetlands encompassing seagrass beds, mangrove forest and intertidal mud flats, habitat for a range of significant migratory water birds, reptiles and mammals.

The Port Corporation is on the record for seeking a reduction of the GBRMP area and have proposed a significant increase in the scale of development in the port.

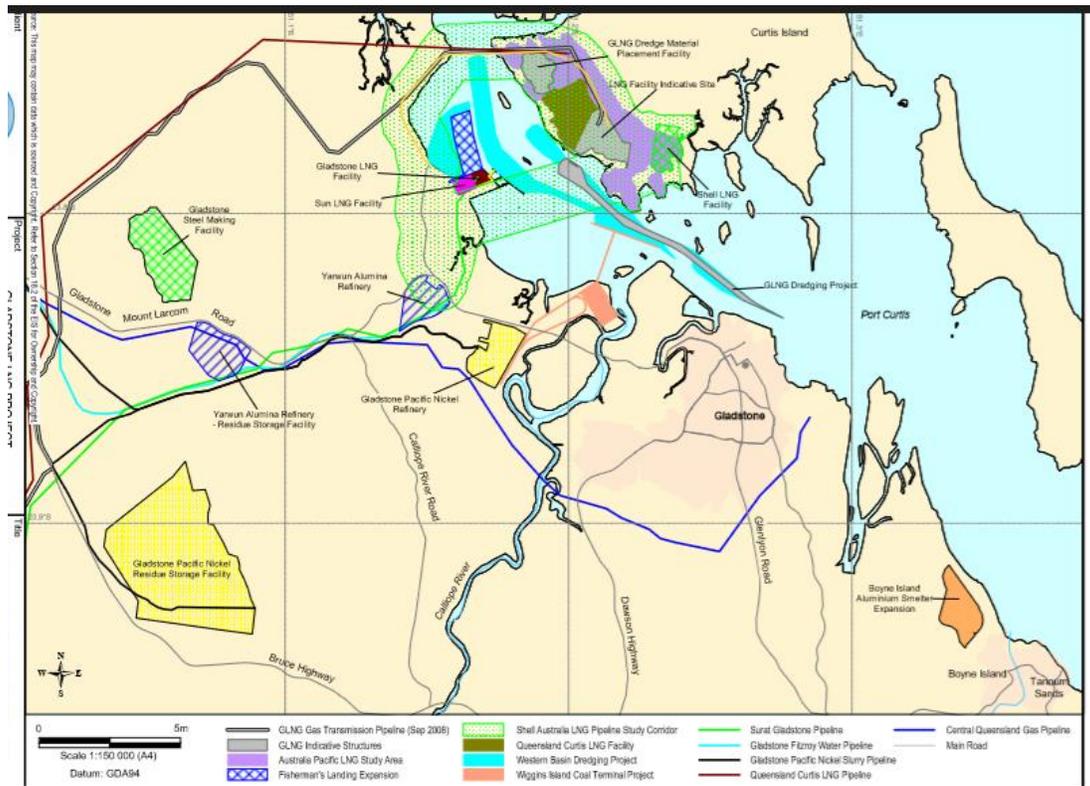


Figure 3. Scope of development in Gladstone Harbor and surrounds

Despite the risks of this development on the marine and littoral environments, Commonwealth approval was given without adequate management of the risks being conditioned. The Commonwealth has subsequently made conditions to the parties to deal with these issues but allowed years to transpire before the finalization of these plans. For example, the QCLNG Project was not conditioned to prepare an 'Aquatic Values Management Plan' until 2015 after the construction of the facility. While management actions such as monitoring are now underway, this work suffers from a lack of any baseline data from which to make sense of the impact from the LNG development.

The proposed expansion of port development in the Great Barrier Reef World Heritage Area (GBRWHA) prompted the World Heritage Council to review Australia's management of the GBRWHA in 2012, placing the World Heritage status of the GBR in question. The review expressed strong concerns about the capacity of current governance structures to protect the ecosystems of the GBR, given the unprecedented scale and speed of industrial development along its margins, and highlighted the need to better understand the impacts of such developments on the ecology of the GBR and the local communities whose wellbeing and livelihoods depend on its resources.

According to government assessments, direct interactions with migratory marine mammals (including marine turtles, dugong and dolphins) were expected to be likely. Direct impacts on mangrove communities were also expected to be likely, particularly as part of pipeline trenching activities at Friend and Laird Point, some 35 ha will be removed. Loss of saltmarsh will be in the order of 39 ha. Direct impacts to seagrass meadows are likely due to construction, some 370 ha will be directly affected by the construction of the Wiggins Island Terminal, Fisherman's Landing expansion and the reclamation and dredged areas. These actions will also cause increased turbidity and movement of sediments but

are thought to be 'short-term impacts to marine turtles and dugong' by the Qld Government. Sediment plumes from dredging are stated to be only 500m in extent.

However, despite the claims by proponents that indirect impacts from dredging, construction, and increased ship movements can be managed, they are expected to be significant and cumulative, adding to existing toxin and sediment loads in the harbour. Prior to a development of the LNG facilities, a review of the toxic compound impacts on the GBR found that existing concentrations of organochlorines, hydrocarbons and metals to be high within port environments "...compounds can persist within the ecosystem for decades, bioaccumulating in marine organisms and posing environmental effects to marine life and humans ... Research carried out to date has been fragmented and inconclusive." (Haynes and Johnson 2000).

Development of the LNG facilities in Gladstone Harbour will further exacerbate these biological stressors on the local marine system as increased sediment movement will also increase the transport of toxins into the harbour and the GBRMP.

Example 4: Sea-grasses and dugongs

Seagrass beds are an important source of food for locally occurring turtles and dugongs. Benham et al (2016) found that seagrasses in the Port of Gladstone demonstrate resistance to sedimentation, but growth declines significantly when these species are shaded or buried for prolonged periods, such as may occur after flood events or dredging.

Impacts were proposed to be minimised via silt curtains and other methods proposed to be developed in dredge management plans and construction management plans, though effectiveness of this strategy has not been quantified adequately.

However, these measures do not take into account bio-accumulation and the transfer of compounds into deeper benthic environments. At least four dugong deaths due to unknown factors were widely reported in the media and turtles have been reportedly killed off in "hundreds". How dugong are coping with ongoing activities in the harbour is not known. <https://www.sbs.com.au/news/dugong-deaths-ecological-disaster>

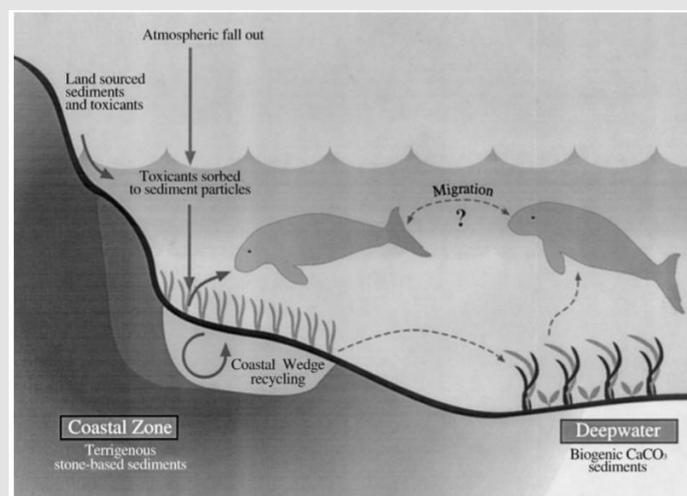


Fig. 2 Conceptual model of pollutant transfer, Great Barrier Reef.

(from Haynes and Johnson 2000)

Example 5: Fish and other kills in Gladstone Harbour

Fish, turtle and dugong deaths, as well as human health impacts reported in the harbour and upstream channels denied by authorities as being caused by dredging. An investigation was launched by the Qld Government into this found that poor fish health was caused by “... *it was flooding combined with the introduction of a significant biomass of fish (including barramundi, mullet, catfish and bony bream) that stressed the ecosystem in Gladstone Harbour and adjacent waterways. This study cannot rule out the possibility that the activity of dredging and associated turbidity provided additional stress to the ecosystem, but it was not the primary stressor.*”

These findings were widely challenged, though subsequent investigations have not been made.

No studies were undertaken on turtles and dugong mortality. Fish mortality and poor condition continued after an official study was completed.

www.abc.net.au/news/2012-01-04/investigation-underway-into-queensland-fish-kill/3758334

<https://www.gladstoneobserver.com.au/news/harbour-fish-crisis-leaves-reef-charter-high-and-d/1165038/>

<http://www.couriermail.com.au/news/more-fish-dying-in-gladstone-harbour-with-hundreds-of-catfish-latest-casualties/news-story/6fa980ed2c6c02a756b09fd616352493>



Dead dugong and ulcerated fish kill from Gladstone harbour

7. TERRESTRIAL IMPACTS

As reliable estimates of actual expected direct and indirect impacts on particular species were not provided in the gas companies environmental impact statements, the Commonwealth placed 'disturbance limits' on the removal of threatened ecological communities and habitat for threatened species listed under the EPBC Act. These limits seem to be based on the extent of such habitat in the study area for each project. In other words, the Commonwealth has mandated the possible removal of substantial area of sensitive habitats within the broader study area for each project. This in itself has serious consequences for local species and community viability.

Table 3. Current extent of Commonwealth disturbance limits on Matters of National Environmental Significance (in hectares)

	APLNG	QCLNG	GLNG	Arrow	GFDP ^A	Total
Brigalow EEC	94.61	88	19.6	106	179	412.21
Vine thicket EEC	4.91	4	0.8	0	190	195.71
Weeing Myall EEC	0	0	0	1	517	518
Coolabah Black Box woodland	0	2	0	8	0	8
Grasslands of QCH and NFB	0	0	5.2	0	288	293.2
Kogan Waxflower		5				5
Belson's Panic Grass		47.5				47.5
Ooline		4				4
Brigalow Scalyfoot	774.22	235	205.3	0	delisted	1214.5
Yakka Skink	73.44	407	119.9	310	4144	4990.34
Dunmalls Snake	262.49	3.4	205.3	4400	2512	7379.79
Collared Delma	0	0	41.6	90	2703	2834.6
Ornamental Snake	0	0	44	0	279	323
Five-clawed worm-skink	0	0	0	560	0	560
Northern Quoll	0	0	100.1	0	4855	4955.1
Koala	0	125.7	0	0	3303	3303
Large-eared Pied bat	0	0	108.1	0	1950	2058.1
Corben's Long-eared Bat	0	105.9	275.4	4,080	4202	8557.4
Water Mouse	0	0	0	5.1	0	5.1
Black-breasted Button-quail	0	0	0.1	0	233	233.1
Red Goshawk	0	0	139.4	0	2425	2564.4
Pained Snipe	0	0	11.2	5	168	184.2
Squatter Pigeon	0	0	199.2	3261	4032	7492.2
Regent Honeyeater	0	0	0	40	0	40
Australian Bittern	0	0	0	0	168	168
Murray Cod	0	0	0	0	73	73
Fitzroy River Turtle	0	0	0	0	73	73

When the approvals were given in 2010/11, disturbance limits were not always mandated. For the APLNG Project, disturbance limits for transmission line impacts were established in 2012, requirements for disturbance limits for the gasfield were not put in place until 2013.

For Santos' Gas Field Development Project which involves large areas of potential habitat, the Commonwealth did not place disturbance limits at all on any of the sensitive matters, but required Santos to merely prepare management plans for each stage of the development including estimates of direct impact.

Table 4 compiles the Commonwealth's disturbance limits and has used the maximum disturbance area for the GFD Project, as these have been determined in a similar way to the disturbance limits and would include areas of indirect impact.

Noticeable are the absence of limits for most fauna species in the APLNG and QCLNG project areas, which is unusual because of the similarity in the habitats being affected across all projects. Impacts on the Koala was not considered by proponents or Qld Govt until after it was listed as a threatened species by the Commonwealth. It is not known how much Koala habitat was removed in the other companies impacts.

Impacts on the Dawson River are included in the assessment of Santos' expansion, though were not considered for the APLNG project even though work is being proposed in this catchment.



Figure 4. Impacts on koala habitat have only recently been considered

Example 6: Brigalow EEC

Of an estimated original extent of 7,324,560 hectares approximately 804,264 hectares (661,314 ha in Queensland and 142,950 ha in New South Wales) remains. Thus nationally, the endangered Brigalow (*Acacia harpophylla* dominant and co-dominant woodland) has declined to approximately 10% of its former area. Others have put this down to 5% in central areas of Queensland.

In their assessments, proponents have measured impact on this community in terms of extent of direct impact in relation to the total extent of the community in the bioregion.

“For brigalow, and semi evergreen vine thicket, the GLNG and QCLNG projects are claimed to account for clearing of 0.03 per cent and 0.16 per cent respectively of these communities in the bioregion. APLNG indicates that its total clearing footprint will only take about 0.5 per cent of the vegetated area in its potential gas field, but that (it) ... may cause fragmentation of some vegetation types.” (C-G Report for GLNG Project).

However, to make any ecological sense of magnitude of impact, particularly for endangered communities, loss of vegetation should be considered local context. Many patches are small and isolated and by themselves are not large areas of land but should be scored highly for sensitivity as important genetic and biological sites which should be preserved, hopefully to form the basis of restorative actions. The approach taken will promote the complete loss of Brigalow from certain locations, further fragmenting an already highly fragmented ecosystem.

With subsequent gas field expansions, the total area of Brigalow potentially affected has increased three-fold, though it is likely the actual area of direct and indirect impact on these ecological communities is not accurately known. This is mainly due to inadequacies in the field verification and mapping products used and missing development footprints in the EISs. Because Brigalow woodland is often found in small patches, they are often not counted as being part of a recognised Regional Ecosystem for mapping purpose and so often not reported.



Brigalow is a highly cleared and fragmented community

Example 7: Threatened Reptiles

The Southern Brigalow Belt is a hotspot for reptiles. All five of Australia's lizard families, four of the six snake families are represented in the highly fragmented bioregion and several are regarded as regional endemics (only occurs in the Southern Brigalow Belt).

Endangered Dunmall's Snake *Furina dunmalli* is known from remnant vegetation communities, which are contiguous with the communities within the gas fields, including Expedition National Park. This species has also been recorded from Taroom area near Isla Gorge National Park. It may potentially occur in all CSG fields.

Similarly, the Collared Delma *Delma torquata*, Yakka Skink *Egernia rugosus* and Brigalow Scalyfoot *Paradelma orientalis* have been recorded from vegetation communities contiguous with habitats within the CSG fields. These are IUCN-listed species, though the Brigalow Scalyfoot was taken off the threatened species list by the Commonwealth in 2013 due mostly to insufficient data, though is still recognised as being 'vulnerable' by the IUCN.

The GLNG gas field alone will directly and indirectly affect thousands of square kilometres of suitable habitat for these species according to latest assessment by Santos (Santos 2016a).



(Left) Brigalow Scalyfoot and (right), Dunmall's Snake

Worley Parsons presented an assessment of the reptile surveys undertaken for the three initial LNG projects to the Environmental Institute of Australia and New Zealand (Worley Parsons 2013) and found significant potential cumulative impact based on the disturbance limits in the consents. They considered the surveys undertaken for the gas companies to be deficient due to a lack of adequate survey to commonwealth standards, lack of expertise of surveyors, deficiencies in mapping and lack of ground-truthing of habitat suitability for individual species.

Example 8: Water Mouse

The Water Mouse is a rare species inhabiting the littoral zone around northern Australia where it feeds on crustaceans. It is a threatened species in several state jurisdictions under the EBC Act and listed by the IUCN as 'vulnerable'. The Queensland Government was not presented with any evidence of the existence of this species in mangroves in the Gladstone area at the time of the project approvals.

However, this species was discovered by gas industry consultants Biodiversity Assessment and Management in 2011, the final report was presented as a management plan in 2012, post approval. It revealed that several animals were caught on Curtis Island and on adjacent areas of the mainland in 2011, constituting a new population.

Incredibly, despite assessments from earlier work, habitats in the area of the LNG Plants were recorded as being of low-moderate quality for the Mouse at the time of the EISs. The GLNG Project EIS concluded that it is "...*unlikely that this species is present on the mainland coast near Gladstone due to industrial and recreational impact*".

Following the discovery of the animal, the Commonwealth then stipulated management plans by all three operators in the harbour. For example, the Commonwealth provided QCLNG condition for a Water Mouse Management Plan in 2012. But, the approval of the Arrow facility on Curtis Island in 2013 gave further permission to clear more Water Mouse habitat (limited to 5.1 ha), along with a financial obligation to 'offset' the impact.

But at the time of the approvals of the three major players' proposals, inadequate pre-clearing surveys had been carried out and the species was not included in any subsequent monitoring surveys because it did not form part of the original consent. The impact of the Gladstone Harbour development on this newly discovered population is not known.



The water mouse, *Xeromys myoides* was discovered in Gladstone harbour in 2011

8. OFFSETS

Both state and Commonwealth consent authorities imposed offset conditions for the projects. These are supposed to promote improvements in biodiversity such that the loss of certain areas of threatened species habitat or ecological communities is compensated. Neither to Qld or Commonwealth legislation requires offsetting on native communities which are not listed as being threatened.

Both state and federal authorities required that environmental offsets be secured by the proponent in a manner that achieves a “no net loss” for biodiversity, in an acceptable manner and timeframe. This is usually done before environmental consents are issued, but approvals in these cases were hurried through prior to their finalisation.

8.1 Curtis Island Offsets

Offsets for combined impacts of the LNG plants and associated activity on the marine environment, World Heritage and Curtis Island were finalised in 2013. This included one substantive land offset ‘Monte Cristo’ and a number of other ‘indirect measures’ such as a Turtle Management Plan and various management and financial commitments.

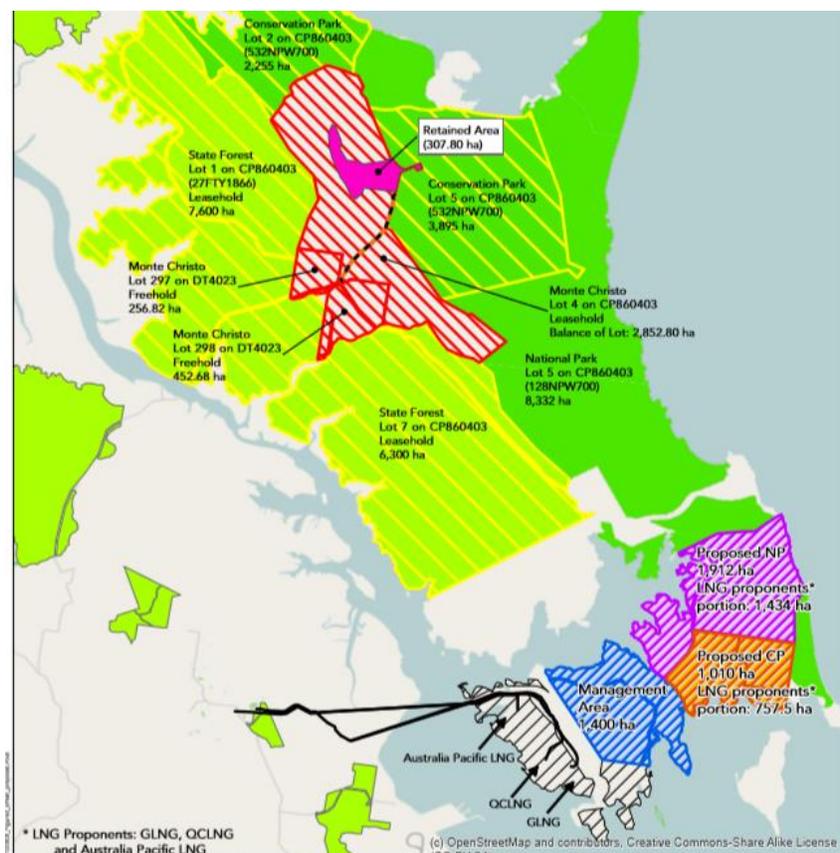


Figure 5. Offset arrangements on Curtis Island

The lands bought are supposed to offset the impacts on the littoral and offshore marine environment, though offsets are entirely within a land-locked portion of land on the island, little bigger than area of direct impact. One other block is to be transferred to the national park estate in 127 years.

8.2 Offsets for gasfield and pipeline impacts

The offsets for the direct impacts of the gasfield, pipeline and other infrastructure and actions are not finalised 6-7 years after the approval was given. This is still a net loss for threatened species and ecosystems in the bioregion.

The APLNG Project has mostly not met its land-based offset requirements, with insufficient offset for a number of key endangered matters such as Brigalow woodland. The APLNG pipeline and gasfield offset requirements for *Cycas megacarpa*, including translocating up to 2,800 plants were not finalised until 2014 as was the offset for Brigalow EEC of 1000 ha, which has to be finalised within 4 years (2018).

Table 4. Reconciliation for Commonwealth terrestrial offset requirements

	APLNG ^A	met	QCLNG	met	GLNG	met	Arrow ^B	met
Brigalow EEC	1000.2	no	755	yes	196	yes	112	no
Vine thicket EEC	41.4	no	20	yes	6.4	yes		
Weeing Myall EEC								
Coolabah Black Box woodland							30	no
Grasslands of QCH and NFB					41.6	no		
<i>Philothea sporadica</i>			120	no				
<i>Cycas megacarpa</i>	200	yes	110	no				
Brigalow Scalyfoot	774.2	no	235	yes	205.3			
Yakka Skink	73.4	yes	372.3	yes	119.9	yes	80	no
Dunmalls Snake	262.5	no			205.3	yes	230	no
Collared Delma					41.6	yes	42	no
Ornamental Snake					44			
Five-clawed worm-skink							6.5	no
Northern Quoll					800.8	yes		
Koala			29	yes				
Large-eared Pied bat			864.8	no	765	yes		
Corbens Long-eared Bat			2263.2	yes				
Water Mouse								
Black-breasted Button-quail			0.8	no				
Red Goshawk					1115.2	no		
Pained Snipe					89.6	no		
Squatter Pigeon					1593.6	no	545	no
Regent Honeyeater							4	no

^A APLNG offset reconciliation from 2015; ^B Arrow are not required to finalise offsets until 2018

Following requests to the Commonwealth for an extension of time to fulfil its offset conditions, the Gas Field and Pipeline Offset Plan was submitted by QCLNG to the Department on 26 May 2014. Further offset requirements for *Cycas megacarpa* were conditioned in 2015. The 'Valkyrie Offset Area Management Plan', Version 3 was approved on 15 August 2017. Shell claimed in 2017 that all offset commitments have been met by the purchase of this property appears to be insufficient for some species.

Arrow Energy's stage 1 project was given an offset requirement by the Commonwealth in 2017, four years after approval. Matters have to be finalised prior to commencement of stage 2, but has no other time limit.

For the GLNG Project, Santos obtained some land-based offset centered on, "Springwood", which resolves most issues for this project, but offsets for the large gasfield expansion of 2016 remain unresolved.

For all of the unconventional gas projects, approvals have been undertaken in a staged way. For each stage, the Commonwealth identified disturbance limits and offset conditions and time limits for meeting the offset requirement. For Arrow Energy, the initial approval included disturbance limits only, though offsets were scheduled in 2017. For Santos' GFD Project, which is a gasfield expansion over an enormous amount of land (680,000ha), no disturbance limits or offset targets were identified by the Commonwealth. Instead, because the approved area is so large, it itself will be broken down into stages and impact assessments will be undertaken by Santos prior to the start of each stage which will include an assessment of any 'residual impact'.

Santos' consultants point out in their Stage 1 report (Santos 2016b) there is no way to measure 'residual impact' at each stage, rather any apparently small impact has been deemed 'non-residual'. For example, only eight hectares of Brigalow EEC are expected to be deliberately cleared in Stage 1 of the GFDP, but because each patch was small in area and 'degraded' compared to other woodland elsewhere, their removal would be a non-residual impact and would not require offset. This is contrary to the Commonwealth's Significant Impact guidelines which defines any removal of EEC as significant, where other measures taken mean it cannot be avoided. Under Queensland law, criteria for a residual impact has with it allowable lower limits depending on stand structure and whether the impact is linear or not.

By eliminating any need to avoid endangered communities or consider indirect impacts, this can only contribute to the local extinction and further decrease in extent and quality of listed sensitive matters. This change of approach in the way approvals were conditioned has only favoured the proponent who now claims to be able proceed with little obligation for offsetting. Instead, like the previous applications, the Commonwealth should have required Santos to make an application based on the Stage 1 area only so disturbance limits and offsetting targets could be identified in a timely manner.

8.3 CSIRO assessment of ecological impacts of unconventional gas

A CSIRO report in 2016 (Ponce Reyes, et al 2016) looked at the potential impacts of the coal seam gas industry development within the Brigalow Belt bioregions. They found that:

- *Even though impacts from the CSG industry is predicted to be smaller than the historical impacts from agriculture and / or urban development, further use of an already highly transformed region can have significant impacts on biodiversity and will add to existing threatening processes in the region, such as clearing and fragmentation of native vegetation, increased invasive species and fire risk and changes to the hydrology of groundwater-dependent ecosystems.*
- *Existing declines in the density and distribution of amphibians, reptiles, birds and medium to large mammals are likely to be exacerbated by indirect impacts arising from CSG development.*
- *The water extraction and treatment process may impact on threatened ecological communities*
- *While CSG developments are regulated to avoid, rehabilitate and offset damages, being a relatively recent and rapidly developing industry, the long-term impacts of the CSG industry on biodiversity remain largely unquantified, with no comprehensive peer-reviewed studies yet in Australia.*
- *The effectiveness of mitigation strategies are not always fully understood nor measured in relation to cumulative impacts at a landscape scale. Biodiversity offset projects are challenging to implement successfully and there is typically a time lag until suitable habitat is created which can result in the loss of dependent species.*

The Report nominates 11 key actions to halt the decline of biodiversity in the Brigalow Belt bioregions, the foremost being, 1. to protect remnant vegetation, 2. protect important regrowth vegetation, and 3. to establish key biodiversity areas, such as identify and manage areas of critical habitat. The growth of the unconventional gas industry in Queensland has failed to adequately take into account these regional conservation priorities.

9. CONCLUSIONS

Approvals were awarded to the CSG industry in Queensland and by the Commonwealth without prior adequate knowledge of ecological impacts on terrestrial, groundwater and marine environments. This has had a number of serious flow-on consequences for the ecology of the region:

- Assessments were undertaken using largely unverified site data and without consideration of indirect (offsite) or cumulative impacts.
- Assessments undertaken by industry and government indicate high risk for (a) impacts on groundwater from gasfield and transmission line development and (b) impact on the marine environment from the extensive harbour development.
- Growing anecdotal evidence suggests that ‘unintended’ impacts have and are still occurring, particularly on the marine animals of Gladstone Harbour, part of the GBRMP; from surface gas seepage and water table drops and their impacts on natural and human users particularly in the Condamine area; and from the extent of habitat fragmentation and local surface water contamination throughout the gasfields.
- Offsets have not taken into account these indirect, marine and unintended impacts, though could have been through an identification of a spatial impact and by using a precautionary approach. These impacts are likely to be considerable but remain unquantified. Offsets which were enforced on companies are based on poor information. Their requirement is now contested by the companies involved. As a result, impacts on sensitive (including IUCN-listed) matters remain unresolved many years later and consequently have failed the ‘no net loss’ test.
- The intended expansion of gas fields by all companies will further exacerbate the existing issues on a regional scale in a bioregion already widely recognised as being under stress. Long-term consequences remain unknown.
- The key issue of impacts on groundwater and its ecological consequences could never have been assessed properly due to the lack of detail provided by the companies. Recognition of many of these short-comings by the Independent Expert Scientific Committee in December 2014, along with other consent anomalies, should throw into question the legitimacy of the original approvals.
- Given these circumstances, a judicial review of the way the development of the unconventional gas industry was conducted by Queensland and Commonwealth authorities is urgently required.

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