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By Email: Alexander.Scott@planning.nsw.gov.au

Dear Mr Scott

INLAND RAIL – NARRABRI TO NORTH STAR (N2NS)
INDEPENDENT REVIEW OF HYDROLOGY AND FLOODING IMPACT ASSESSMENT
FINAL REVIEW REPORT (REVISED) FOR SEPARABLE PORTION 1 (SP1)

This report summaries the principal findings of our review of the hydrology and flooding issues associated with the upgrading of 171km of railway track between Narrabri and North Star (**N2NS**), excluding works over the Mehi–Gwydir floodplain in the vicinity of Moree.

This portion of the Inland Rail programme is referred to as Separable Portion 1 (**SP1**) of the N2NS sector. It excludes the upgrading of 15km of track crossing the Mehi–Gwydir floodplain and the building of 2.3km of new track at Camurra, which is known as Separable Portion 2 (**SP2**).

We understand that the division of the work into SP1 and SP2 has occurred due to design complexities associated with flood management around Moree within the SP2 area.

Background to this Final Review Report

The Department has identified hydrology and flooding as some of the key environmental issues associated with the Inland Rail programme. There are 13 sectors of the programme of which seven are located within NSW.

In October 2017 we were commissioned by the Department to undertake an independent review of the hydrology and flooding components of the N2NS sector. The construction and operation of the N2NS sector is referred to as 'the **Project**' in this review.

Over the course of the almost three years since 2017 we have participated in numerous meetings between the Department and the Proponent, Australian Rail Track Corporation (**ARTC**). During this time we have reviewed various stages of the impact assessment reports that have been produced by ARTC and provided written advice to the Department on many aspects of the N2NS sector as the project has been formulated and documented.

In preparing this final review report the Department requested advice about the Project as documented in the Submissions Preferred Infrastructure Report (**SPIR**) including ARTC's subsequent responses to issues raised by State agencies following public exhibition of the SPIR. The specific matters about which the Department requested our advice comprise:

i. adequacy and completeness of the hydrology and flood impact assessment;
ii. compliance of the project with applicable legislation and guidelines;

iii. adequacy and appropriateness of the management and mitigation measures recommended for the project; and

iv. recommended actions and conditions of approval that could be applied to avoid, minimise, mitigate, and/or manage the residual hydrology and flood impacts (should the Department recommend approval of the project).

Documents Reviewed

Various documents have been provided for review. Of those documents the following are the most relevant:

(a) *State Significant Infrastructure Application Supporting Document*, January 2016, prepared by GHD for ARTC;

(b) *Secretary's Environmental Assessment Requirements* (**SEARs**), 8 November 2016;

(c) *Environmental Impact Statement* (**EIS**), Inland Rail Programme, Narrabri to North Star Project. Main Report (undated);

(d) *EIS Technical Report 6 – Hydrology and Flooding Assessment* dated October 2017 prepared by GHD for ARTC. This report is subsequently referred to as '**TR6'**;

(e) ARTC's responses dated 22 June 2018 to a list of issues that the Department had previously forwarded to ARTC. These included issues raised by the then Office of Environment and Heritage (**OEH**) and ourselves;

(f) *SPIR Main Report* (undated);

(g) *SPIR Flood Study Report* dated August 2019 including the various attachments listed in the Department's email to us on 16 December 2019. Note that the majority of this document had previously been reviewed in August 2019. Some of the attachments which were of most relevance to this review included:

- Attachment D – *Cross Drainage Structure Blockage Assessment*
- Attachment E – *Hydrological Calibration Report*
- Attachment F – *Flood Impact Assessment for Extreme Events*

(h) ARTC's responses to a list of issues that the Department had previously forwarded to ARTC on 19 November 2019.

REVIEW FINDINGS

Overview

The Department has provided feedback and held meetings with ARTC during which issues with the hydrology and flooding approach were raised. These meetings were held prior to, and subsequent to, the release of the EIS and SPIR documents. There was only limited additional information relating to flooding and hydrology provided in the SPIR (which is for SP1) compared to the EIS (which was prepared prior to the division of the Project into SP1 and SP2).

However ARTC have separated the N2NS work into two portions which may allow more time for the very significant flooding impacts around Moree to be addressed in SP2. Nevertheless there are many issues of approach which are common to both SP1 and SP2 and consequently the review comments which are made here, whilst they relate only to SP1, will likely also be applicable to SP2 in many cases.

Because of deficiencies in the SPIR documentation and assuming that approval for SP1 is granted, we have drafted conditions for consideration by the Department to address these deficiencies. These draft conditions have been forwarded under separate cover.

Assuming these draft conditions or similar conditions are applied, and having regard to the specific matters (i) through (iii) above, it is our opinion that there are no hydrology or flooding issues preventing approval of the SP1 Project.

In the remainder of this letter we provide our assessment of the key hydrology and flooding issues associated with the SP1 Project.

1. Flood Planning Level (FPL) / Flood Immunity / Flood Standard

1.1. ARTC have defined the term 'flood immunity' as the flood which rises to the top of the rail formation. At this level water will start to pass through the ballast. As the water level rises further, the propensity for water to wash away ballast will increase. Assuming significant erosion of ballast does not occur, water may eventually rise high enough to overtop the rail itself.

1.2. The EIS and SPIR documents don't provide an assessment of the height to which water needs to rise above the formation before damage occurs, or is likely to occur. Supposedly some increase in water level above the formation could occur without any impact on train operations or damage to the infrastructure. Consequently by evaluating only the flood immunity (as ARTC have defined this term) when considering the impact of floods on the rail infrastructure, the EIS and SPIR over-estimate the adverse impacts of floods on train operations.

1.3. For the purposes of N2NS we have defined an additional term i.e. 'flood standard'. This is the flood event which stops trains and/or significantly damages the infrastructure such that train operations are disrupted. In our opinion it is important for the Department to know the minimum flood standard that will be achieved through approval of the Project.

1.4. Although ARTC's flood immunity assessments over-estimate the flood impacts, some of the assessed immunities are very low (e.g. 10% AEP).

1.5. Having regard to other major infrastructure projects including highways, a flood standard more frequent than 1% AEP (or more frequent than 1% AEP with climate change) would be inconsistent with normal practice and is likely to be inappropriate.

1.6. Based on the EIS and SPIR documents, the actual flood standard is unknown because the potential erosion of ballast by water rising above the formation has not been assessed. Nevertheless ARTC have assessed that provided the ballast is not washed away, flood waters would not overtop the rail in any location during a 1% AEP event. Checks also indicate that water would not overtop the rail even under 1% AEP climate change conditions provided the ballast is not eroded.

1.7. The failure to assess the ballast erosion potential means the actual flood standard is unknown.

1.8. The NSW Floodplain Development Manual (the **Manual**) sets out the process by which the flood immunity / flood standard for the Project should be selected. The process requires the Proponent to evaluate the social, economic, technical, flood risk and environmental implications of adopting different immunity standards. It doesn't appear that this process has been undertaken for the N2NS sector (or for the Inland Rail programme as a whole). ARTC has applied a multi-criteria analysis (MCA) process to

inform their "business decision on rail flood immunity"[1] but this process doesn't appear to consider the costs of raising and the benefits of improved train operability and therefore is not fully consistent with the process in the Manual.

1.9. In our opinion, it is also inappropriate for the flood immunity / flood standard of individual lengths of the N2NS sector to be determined after approval of the Project, and in isolation of the sector as a whole (or in isolation of the immunity/standard of other sectors). This is because the immunity/standard of a route can be no higher than the lowest immunity/standard of any individual part within that route.

1.10. In our opinion, determination of the flood immunity / flood standard should be carried out strategically during feasibility studies prior to the EIS. The normal practice for major infrastructure projects is for the flood immunity / flood standard to be established within cost-benefit studies prior to commencement of the EIS and not during detailed design.

1.11. It is inappropriate to leave determination of the flood immunity / flood standard of individual lengths of a sector to detailed design. This is an ad-hoc approach to planning and is unlikely to achieve optimum outcomes for the Inland Rail programme or the community. It may necessitate subsequent and expensive raising of the rail level in the future particularly if rail traffic increases and the cost of disruptions due to flooding become more significant.

2. Flood Immunity Constrained by Elevations of Existing Road Crossings

2.1. The EIS states that the flood immunity of the rail line was also constrained by the elevation of existing level crossings. The authors of TR6 state that one of the design requirements for the Project was "*maintaining the existing track elevation at level crossings*".[2]

2.2. No justification of this design requirement appears to have been provided. Whilst it will minimise the extent of road upgrading works, this of itself may be insufficient justification.

2.3. The upgrading of the rail line provides an opportunity for both the flood immunity of road and rail to be improved. This issue should have been looked at strategically in the EIS (or within feasibility studies prior to the EIS).

2.4. The flood immunity of any existing road which crosses the rail line is constrained by the rail elevation at the crossing location. The requirement that the rail levels now remain at the existing elevations at these crossings, removes the opportunity for road authorities to ever raise their roads.

2.5. This concern about flood immunities at road crossing locations has been previously raised with ARTC and it had been anticipated that the issue would have been addressed in the SPIR. However it is unclear to us whether this has occurred or not.

3. Spoil Mounds

3.1. There is little information about spoil mounds in the EIS and the impact of spoil mounds on flood behaviour has not been addressed. Based on the EIS we understand most or all of these will be permanent structures and it is likely that there would be spoil mounds along the majority of the length of the rail line.[3]

3.2. If any of these mounds are to be located on flood prone land there is potential for impacts to occur.

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[1] Section 1.3, Appendix E, SPIR.
[2] Section 2.3.1, page 9 of TR6.
[3] We understand that rather than removing excavated materials (e.g. unwanted ballast or overburden from the existing formation) to a common disposal site or sites, distant from the rail corridor, the material will be placed in spoil mounds along the majority of the rail corridor.

3.3. It appears from the SPIR that it is still not known whether these spoil mounds will be required (and their size and location). Nevertheless the SPIR states that the spoil which is placed within the rail corridor, will not be placed within areas where the placement would adversely affect flooding.[4]

3.4. The design and location of any spoil mounds required would be confirmed during finalisation of the detailed design, when the location and volume of spoil material is better understood. Location of any potential spoil mounds on floodplains will need to be carefully addressed in the conditions.

3.5. We expect that as part of the feasibility studies for these types of projects, the quantum of spoil would have been estimated and the preliminary sizes and locations of spoil mounds would have been determined.

4. Quantitative Design Limits (QDLs) for Flood Impacts

4.1. Quantitative Design Limits (QDLs) are important because they define the maximum acceptable changes in relevant flood parameters such as velocity, duration, water levels, etc. Because these limits may be used as a trigger for design modifications, acquisition of additional corridor land, payment of compensation, etc, the limits need to be carefully formulated, justified and documented.

4.2. Derivation and agreement on QDLs has been a major issue for discussion between the Department and ARTC at the various meetings which we have attended for the N2NS Project.

4.3. There were no QDLs for flood impacts provided in the EIS. In our opinion, the absence of the QDLs was a serious shortcoming of the EIS.

4.4. After the EIS was exhibited, ARTC responded by providing Flood Management Objectives (**FMO**s) including those published within the SPIR. In our opinion, except possibly for Attachment F of the SPIR (which still contains shortcomings), the FMOs provide an inadequate basis from which to assess flood impacts for a major rail infrastructure project.

4.5. In our opinion, it was inappropriate for ARTC to have allowed the project to proceed to the current stage without having the QDLs/FMOs settled. Consequently the assessment of impacts presented in the EIS and the SPIR are based on ARTC's FMOs and, as a result, a rigorous assessment of impacts (i.e. based on more robust limits) has not been provided and the implications to the Project are not fully known.

4.6. We have prepared QDLs which are appropriate for this Project and these are provided in **Table 1** and should replace the FMOs in the SPIR**.**

4.7. The SPIR also provides commentary on what should occur during detailed design if the QDL/FMO limits are exceeded. This includes examples of where the limit can be disregarded if the Proponent or designer considers the exceedance of a limit to be minor or immaterial in the particular circumstances of the exceedance. We disagree with this approach and recommend that such exceedances require approval of the affected land owners and may also require additional mitigation works to be constructed.

4.8. In regard to the various QDLs in **Table 1**, a few require further commentary:

(a) *Velocity Limit*: – Concerns remain over whether the rail corridor is sufficiently wide to contain the necessary scour protection measures that will be required downstream of culvert outlets and thus prevent off-site impacts. The finer scale hydraulic modelling downstream of these outlets which has been requested on numerous occasions has not been provided in the SPIR. The geotechnical and geomorphological assessments

[4] Section 7.4 of SPIR in response to submission on spoil mounds raised by the then OEH.

relating to scour potential have also not been provided. The inconsistencies with the Government's Rural Floodplain Management Plans (**RFMP**s) have not been resolved. Additional land acquisition or easements will likely be required in some locations.

(b) *Afflux Limits*: – Floor levels have also not been surveyed and appear to be estimated from ALS/LIDAR. Consequently there may be other buildings affected above floor level.

(c) *Risk to Life / Hazard Limits*: – Limits relating to water over roads have not been settled. Whilst consultation with road authorities has been undertaken, consultation about specific limits does not appear to have occurred. Water over roads also causes a safety risk due to aquaplaning of cars at speed. This additional safety risk has not been considered.

5. Consideration of Risk to Life in Extreme Floods

5.1. The collapse of large sections of the rail embankment in a 0.05% AEP flood is acknowledged in Attachment F of the SPIR. Such collapses will also occur in rarer floods.

5.2. Because a number of floods more frequent than 1% AEP will rise into the ballast above the top of the rail formation, it is also possible that ballast could be washed away in these floods. (The propensity of the geotechnical design to resist collapse in these floods has not been described despite the Department's previous requests to ARTC for further details).

5.3. Attachment F documents two residential settlements and a number of other 'isolated buildings' located downstream of rail sections that could collapse in large floods. However the assessment of risk to life has not been provided. It is not known how the risk to life to people in these buildings will be safely managed, noting that this risk is created by the Project.

5.4. If the Project is approved, careful consideration will need to be given in the conditions of approval to ensure these matters are addressed so that risks to life are mitigated to an acceptable level within the final design.

6. Blockage Assumptions for Culvert Design

6.1. The blockage assessment in Attachment E of the SPIR has considered two mechanisms for culvert capacity to be reduced by blockage. These are sediment build up inside the culverts and the obstruction of culvert inlets by water borne debris from upstream.

6.2. In our opinion, the second mechanism presents the main blockage risk. However ARTC's assessment of this mechanism assumes grasses are the principal blockage component and has ignored tree branches and logs that might be mobilised in a major flood. Consequently in our opinion the calculated blockage values and the resultant culvert sizes are under-estimated.

6.3. A revised design which properly accounts for blockage will then result in larger culverts. These larger culverts will have ramifications for other parts of the Project including altering the assessed flood impacts and the modelled flow distributions (including those which might occur when the culverts are unblocked).

6.4. These deficiencies in the design will need to be addressed in the conditions of approval, if the Project is approved.

7. Peer Review of Flood Modelling

7.1. No independent technical review of the hydrological and hydraulic modelling has been undertaken and reported. It is normal practice for this to occur because the modelling provides critical base data that underpins the environmental assessment of flooding and hydrological impacts.

7.2. If the project is approved, there will need to be a condition of approval to require the peer review to be undertaken.

8. Other Issues

8.1. Geomorphological impacts receive scant attention in the EIS and the SPIR. Significant changes in flow behaviour have the potential to adversely impact the geomorphology of existing landforms and watercourses. A particular concern is where new flowpaths are being created (i.e. downstream of new culverts where previously there were no culverts through the existing formation) or where velocities will be increased beyond the limiting scour velocity of the in-situ material.

8.2. The introduction of new culverts and the creation of new flowpaths are also likely to be a key concern to the landowner because of the potential impacts on agricultural productivity, farm operations and farm dams. Consequently conditions of approval to address these on-farm issues and the geomorphological impacts are required if the Project receives approval.

8.3. The propensity for in-situ soils to erode downstream of culverts where flows are being introduced, or where flows are being increased, requires closer attention. This is particularly the case given the presence of black clays in some areas.

8.4. Geotechnical assessments of the erodability of the soils are not presented in the EIS. The limiting scour velocity of 1m/s in the SPIR is too high in many circumstances. We recommend that a limiting velocity of 0.5m/s be adopted unless site specific geotechnical assessments have been carried out to determine the limiting scour velocity. (This default limiting velocity of 0.5m/s is that previously recommended by OEH for the N2NS based on the Gwydir and Narrabri-Wee Waa RFMPs and the Soil Conservation Guidelines for Queensland).

8.5. Given potential scour and erosion risks downstream of new culverts beyond the boundary of the rail corridor, we would have expected to see preliminary designs of mitigation works to avoid erosion and scour downstream of culverts. Although these have been requested of ARTC, none are provided in the SPIR. We doubt that in some locations there is sufficient width of land available within the corridor for such mitigation works to be built without requiring works on adjacent private land.

8.6. It is unclear whether the locations of all farm dams have been identified and whether the resultant changes to water inflows to these dams have been assessed. Whilst the QDLs / FMOs do consider changes in velocities and durations during floods at the rail line, any changes in the water supply yield of farm dams will be primarily dependent on the volumes delivered to the dams. Although compliance with the velocity and duration QDLs / FMOs will likely mitigate most farm dam impacts, a condition relating to farm dams will be required if the Project receives approval. In particular this condition should address farm dam impacts when new culverts are introduced and new flowpaths are created.

SUMMARY AND CONCLUSIONS

Given that there has been almost three years of liaison between ARTC and the Department over the hydrology and flooding issues associated with SP1 of N2NS, we expected that the outstanding hydrology and flooding issues would have been resolved following the presentation of the SPIR.

Nevertheless the scope of the remaining issues has been narrowed.

In addition we recognise that in considering whether the Project should be approved, the Department must assess a range of issues of which hydrology and flooding are but two. Consequently should the Department determine to grant approval to the Project, we consider that the current deficiencies could be addressed with stringent conditions of approval.

Separate to this review report, a draft set of conditions has been prepared and forwarded to the Department for consideration.

Yours sincerely

Drew Bewsher
Director

TABLE 1: DRAFT QUANTITATIVE DESIGN LIMITS (QDLs)
(These QDLs are only applicable beyond the SSI corridor, unless otherwise noted)

Parameter	Location or Land Use	Limit
Afflux i.e. increase in flood level resulting from implementation of SSI. AEP range: all floods up to 1%AEP Duration range: all durations	Habitable floors[5]	0mm increase above floor level 10mm increase below floor level
	Non-habitable floors[5]	20mm increase
	Other urban and recreational	100mm increase
	Agricultural	200mm increase
	Forest and unimproved grazing land	300mm increase
	Highways and sealed roads >80km/hr[6]	No increase in depth where aquaplaning risk exists and remains unmitigated. Otherwise 50mm increase
	Unsealed roads and sealed roads <80km/hr[6]	100mm increase
Scour/Erosion Potential i.e. increase in flood velocity resulting from implementation of SSI. AEP range: all floods up to 1%AEP Duration range: all durations	Ground surfaces that have been sealed or otherwise protected against erosion. This includes roads and most urban, commercial, industrial, recreational and forested land	20% increase in velocity where existing velocity already exceeds 1m/s
	Other areas including watercourses, agricultural land, unimproved grazing land and other unsealed or unprotected areas	No velocities to exceed 0.5m/s unless justified by site-specific assessment conducted by an experienced geotechnical or scour/erosion specialist. In addition, the increase in velocity is to be limited to 20% where the existing velocity already exceeds 1m/s
Flood Hazard i.e. increase in velocity~depth product (**vd**) and/or flood hazard category resulting from implementation of SSI. (Does not apply where vd>0.1m^2/s). AEP range: all floods up to 1%AEP Duration range: all durations	Urban, commercial, industrial, highways[6] and sealed roadways[6]	10% increase in vd where H1 or H2 category. 0% increase in vd where H3 or greater hazard category.
	Elsewhere	20% increase in vd

[5] Habitable floors/rooms are defined consistent with the use of this term in the NSW Floodplain Development Manual. In a residential situation this comprises a living or working area such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. In an industrial, commercial or other building, this comprises an area used for an office or to store valuable possessions, goods or equipment susceptible to flood damage in the event of a flood.
[6] Including where located within SSI corridor

Parameter	Location or Land Use	Limit
Flood Duration i.e. increase in duration of inundation resulting from implementation of SSI. (Does not apply to inundated areas less than 100m^2). AEP range: all floods up to 1%AEP Duration range: all durations	Habitable floors[5]	No increase in inundation duration above floor level. 10% increase in inundation duration where below floor level and when existing inundation duration exceeds one hour. Otherwise inundation duration not to exceed one hour.
	Highways and sealed roads >80km/hr[6]	10% increase in inundation duration.
	Elsewhere	10% increase in inundation duration when existing inundation duration exceeds one hour. Otherwise inundation duration not to exceed one hour.