NORTH STAR TO NSW/QLD BORDER (NS2B)

INLAND RAIL PROJECT

DESKTOP STUDY ON FLOODING & GROUNDWATER

FINAL VERSION

STEPHEN N WEBB & ASSOCIATES PTY LTD

1. PREAMBLE

This is a Desktop Study which has been carried out by Stephen N Webb & Associates Pty Ltd ("**SNW**") at the request of Holding Redlich ("**HR**"). HR are acting for a group of 6 Landholders (the "**Landholders**"), who adjoin the rail corridor. Their lands extend from approximately seven kilometres north of North Star to the NSW/QLD border, and in some cases are located on both sides of the rail corridor (**Figure 1**).

Because of the short time we had available, SNW have had to rely on the technical results contained within the EIS, after critical review, and have also considered the Independent Review by BMT dated 12 May 2020, and the Submission to the Senate Inquiry by Dr Sharmil Markar.

As part of the Brief from HR, we were provided with a list of "Landholders Concerns", which we have attached to this Study as **Annexure 1**.

This review considers **EIS Chapter 13** and Future Freight Joint Venture's Appendix H – Hydrology and Flooding Technical Report ("**FFJV's Report**") dealing with surface water and hydrology. The Secretary's Environmental Assessment Requirements ("**SEARs**") under "8. Flooding, Hydrology and Geomorphology", and "9. Water – Hydrology", have been reviewed. The SEARs are comprehensive, and also make reference to the need to consider impacts on groundwater hydrology. We have therefore considered **EIS Chapter 14** and FFJV's Groundwater Technical Report when we cover groundwater issues in Section 10 of this Study.

Study Team

- SNW commenced operations in 2004, and have practised primarily in the fields of hydrology, hydraulics and groundwater. A high proportion of the work has involved provision of expert advice on legal matters affecting developments.
- Dr Stephen Webb has led the Team for this Study. He has a PhD in Hydrology obtained from UNSW. He has practised in the relevant fields since 1978. He has been assisted by Ms Nicole Webb, who has a double-degree in Environmental Engineering and Law obtained at UNSW, graduating with First Class Honours and the University Medal in both degrees. She is a Chartered Professional Engineer with over 15 years of experience. The third member of the Team is Dr Christopher Miller, also a graduate of UNSW with a double degree in Environmental Engineering (Honours 1, University Medal) and Science (Chemistry). His PhD in Water Chemistry was awarded in 2012. Dr Miller has worked for SNW on a casual basis since 2005.

Limitations

- This work had to be completed within a short period of time to meet the EIS deadline of 6 October 2020 (later extended to 20 October 2020 for this submission).
- The time period also meant it was not possible to visit the field and inspect the NS2B alignment. It would have been particularly valuable if there had been an opportunity to inspect the NS2B alignment in the vicinity of the Landholders as identified in **Figure 1**.
- It was also not possible for us to obtain and review the hydrologic and hydraulic models to perform a detailed investigation.

2. SUMMARY OF FINDINGS

Our major concerns include:

- We strongly disagree that the 1% AEP flood event, as developed and used by ARTC's consultants, is the appropriate flood event for the assessment of the NS2B design. The flood is not fit for purpose. This is apparent from the choice of parameters, and by comparison with observed floods.
- In large inland river valleys, every storm is different in areal extent, much more so than experienced in coastal river valleys. This makes it difficult to develop a credible 1% AEP flood using normal ARR2019 procedures. If there are large observed floods, which there are in this instance, it is much better to learn from them, rather than develop a synthetic flood.
- We note that the derived 1% AEP flood event results in substantially lower affluxes after construction of the NS2B than predicted for the 1976 flood event. The 1976 flood has been assessed to be a 1.3% AEP flood at Boggabilla (DPIE's Floodplain Management Plan for the Border Rivers Valley Floodplain (2020) ("**BRVFMP**")), suggesting the 1% AEP flood event developed by ARTC's Consultants, underestimates a true 1% AEP flood.
- The 1976 flood event is more appropriate for the assessment of the NS2B proposal, both in terms of the magnitude of the event, and the fact that it has been adopted for Flood Planning Level purposes by Goondiwindi Shire Council and the BRVFMP.
- We also have concerns with the TUFLOW hydraulic model. This apparently does not have local rainfall on grid. This would result in lower flows at the downstream end of the model, and reduced flows impacting on the NS2B where the Landholders are located. Almost all of the Drainage Structures in the vicinity of the Landholders are culverts (see attached **Figure 2**). Their minimum dimensions vary from 900 mm to 1200 mm. ARTC's consultants state that a blockage factor of 25 per cent was applied to culverts (p.100, FFJV's Report). In large floods, such as a 1976-type flood, a large amount of debris would be mobilised in the vicinity of the Landholders. A modelled blockage factor of 25 per cent grossly underestimates the likely blockage of 900 mm to 1200 mm culverts in large floods in the vicinity of the Landholders. If there are inadequate culverts in one section of the line, or if they are partially or completely blocked, flows will divert to culverts or bridges that are not blocked. This would result in increased affluxes and higher velocities parallel to the line, and likely result in scour/deposition within the vertosol soils.
- It is important that the Drainage Structures in that section of the NS2B adjoining the Landholders (see **Figure 1**) be considered as a whole, and fully incorporated in the hydraulic model to have their impact assessed and sizing designed. Precise Drainage Structure locations could then be refined at the Detailed Design Stage in consultation with affected landholders.

- The assessed affluxes on the Landholders' properties, which are in excess of 200 mm for a 1976-type flood event, are not acceptable to the Landholders and are inconsistent with the BRVFMP and ARR2019. It is likely that these affluxes have been underestimated due to the inadequate culvert blockage factor used and failure to consider on-grid flow inputs to the hydraulic model.
- We note that FFJV suggest that "At Detailed Design the benefit of undertaking joint probability analysis should be considered" (p.78, FFJV Report). In our view, a credible joint probability analysis would not be achievable due to the paucity of data in this region.
- A credible flood event (such as the 1976 flood event), with acceptable impacts in terms of flows, levels and affluxes, should be assessed, and issued for public comment prior to the approval of the NS2B EIS.

3. THE DESIGN EVENT MUST BE 1976

The SEARs at Section 8.2(a) requires "*utilising hydrologic and hydraulic models that are consistent with current best practice and utilise topographic and infrastructure data that is of sufficient spatial coverage and accuracy to ensure the resultant models can accurately assess existing and proposed water flow characteristics*". The hydrologic and hydraulic models relied on by ARTC are not consistent with current best practice and have several technical problems which make their "accuracy" highly uncertain.

The SEARs at 8.2(e) requires "*an assessment of the consistency (or inconsistency) with the applicable Council or OEH floodplain management plans. The requirements of these plans must be discussed with OEH and the Council*". ARTC state in EIS Chapter 13 that "*The assessment criteria applied during the EIS process, and documented in the EIS, are generally in accordance with the Floodplain Management Plan (FMP) requirements.*" (p. 13-96, EIS Chapter 13). It is SNW's opinion that ARTC's use of a design flood that results in lower impact than the 1976 flood event is a major departure from the BRVFMP.

The BRVFMP adopted the 1976 flood event as its design event.

Goondiwindi Council use the 1976 flood event for Flood Planning Level decisions.

The BMT Report on p.3 "*recommend that it would be prudent to continue to use the 1976 flood event as a sensitivity analysis/check in subsequent design and to assist with landholder negotiations prior to undertaking the joint probability.*" It is SNW's view that the ARTC must use the 1976 flood event as the Flood Planning Level for the assessment of the NS2B proposed design. Because of the paucity of data in this region, a credible joint probability analysis would not be achievable. Joint probability analysis requires a large amount of reliable data, which is not available in this region.

The conclusion we draw from the above is that it is necessary for the proponent to adopt the 1976 flood event as an absolute lower bound flood for design purposes. Even when this is adopted, it would be a matter of good practice to test the design for larger floods to ensure that no "unexpected" problems arose.

4. HYDROLOGY

4.1. Calibration

Calibrating the hydrologic model flows requires adjusting rainfall loss parameters and catchment-specific model parameters. Table 7.3 from FFJV's Report shows hydrologic model parameters. The Dumaresq River model has different channel lag parameter (alpha) values for the 1996 event (0.2) than that for the 1976 and 2011 event (0.1). The Dumaresq River is historically a major contributor to significant floods in this region (for example, contributing approximately half the flow of the 1976 flood), so uncertainty in this fundamental hydrologic model parameter is significant when attempting to use this model to assess design flows.

Table 7.3 Tributary adopted parameters

Sub-catchment	Alpha	Beta	m
Macintyre Brook	0.20	1.2	0.8
Dumaresq River	0.10 (2011, 1976) 0.20 1996)	1.2	0.8
Macintyre River	0.20	1.2	0.8
Ottleys Creek	0.20	1.2	0.8
Local catchments (Strayleaves, Forest, Back, and Mobbindry Creeks)	0.20	1.2	0.8

ARR2019 Book 7 p.41 states that "*different parameter sets applying for different calibration events…**is not allowable**, since a single parameter set will be required for application… Whichever technique is adopted to interpret the calibration results and adopt parameters for a design application, these adopted parameters should then be used with the model on all of the design flood events to confirm the performance for all the data. The results from this should show at least a reasonable performance for all of the calibration flood events and no bias in the results, that is the calibration on all historic floods should not be all under- or overestimations.*"

The use of a different set of model parameters for different historical flood events is not consistent with best practice; it is not consistent with the ARR2019 guidelines; and it is not allowable.

4.2. Rainfall loss parameters

There is substantial variation in the rainfall loss parameters used for each historical storm for each model. Table 7.4 from FFJV's Report is reproduced below:

Table 7.4 Initial and continuing loss parameters

Event	*Sub-catchment*	*Initial loss (mm)*	*Continuing loss (mm/hour)*
1976	*Macintyre Brook*	*0.0*	*2.50*
	Dumaresq River	*42.9*	*4.34*
	Macintyre River	*36.5*	*2.32*
	Ottleys Creek	*n/a*	*n/a*
	Local catchments	*36.5*	*2.32*
1996	*Macintyre Brook*	*25.0*	*2.00*
	Dumaresq River	*40.0*	*0.94*
	Macintyre River	*26.2*	*0.85*
	Ottleys Creek	*100.0*	*0.85*
	Local catchments	*26.2*	*0.85*
2011	*Macintyre Brook*	*60.0*	*0.80*
	Dumaresq River	*47.0*	*0.50*
	Macintyre River	*50.0*	*3.30*
	Ottleys Creek	*n/a*	*n/a*
	Local catchments	*50.0*	*3.30*

This also introduces uncertainty as to selection of appropriate values to use for design storm simulations. Whilst the embedded design storm approach of ARR2019 mitigates the impact of initial losses to some extent, the variation of continuing loss may have **significant impacts**. For example, continuing losses for Dumaresq River vary from 0.5 mm/h to 4.34 mm/h. This is a technical problem which casts doubt on the accuracy of FFJV's models.

4.3. Rainfall Gauges

The hydrologic models cover a large catchment, within which both spatial and temporal variability of rainfall is to be expected. Table 5.6 of FFJV's Report lists the rainfall gauges considered for each historical event. It is typically beneficial to include as much data as available to inform this spatial and temporal rainfall distribution. However, the 1976 event only includes 7 rainfall gauges (noting that the combined area of the Macintyre Brook, Dumaresq River and Macintyre River hydrological models is 19,968 km^2), only one of which with pluviographic data available (critical for sub-daily distribution of rainfall). We investigated 56139 Ben Lomond (chosen at random) from BOM Weather Station Directory to confirm that at least one of these missing stations is likely to be relevant. There was no missing data or other indication for why this station would be excluded. It is noted that other storm events have considered additional rainfall gauges which also appear to include data for the 1976 rainfall event, yet they have not been considered in the 1976 models. More rainfall data would lead to better predictions from the hydrologic model.

How disaggregation of the daily rainfall to the shorter time periods required in the hydrologic model has been achieved is also missing from FFJV's Report, so assessment of the adequacy of this cannot be made.

5. HYDRAULIC MODEL

5.1. Calibration

FFJV undertook calibration of the hydraulic models by adjusting parameters to obtain best fits to measured streamflow data. For the Macintyre River and Macintyre Brook there are gauging stations located near to the upper limits of the study area, which in principle suggests that a well-calibrated hydrologic model of these catchments may produce reasonable estimates of flows in the study area. However, for the Dumaresq River, which is a major contributor to the large historic floods, the nearest gauging station (Roseneath 416011) is approximately 110 km upstream of the study area. There is therefore considerable inherent uncertainty as to how well even a well-calibrated model may be able to predict flows at the study area (as there is no basis for fitting flows at the outlet of this model).

5.2. Factoring of Hydrologic Model Flows

There is very significant factoring of hydrologic model flows applied for the 1976 and 1996 floods (+20% and +60%, respectively) to achieve a reasonable match to observed levels when these flows are used as input to the hydraulic model:

"
- *The 1976 calibration event flows have been factored up (20%) in the hydraulic model to achieve the calibration at the gauge. It is possible that the rainfall distribution may not have been picked up by the recorded gauges such that the rainfall was underestimated. Table 7.7 shows that while the calibration was reasonable between the recorded and simulated peaks, it was typically lower, suggesting the flows may be lower than those that occurred. DPIE have indicated that the 1976 hydrology will not be revisited due to the uncertainty in changes to catchment conditions between now and 1976.*
- *The DPIE 1996 model is factored up (60 per cent) to achieve calibration levels downstream of Goondiwindi."* (p. 18, FFJV's Report)

It is hard to see how the hydrologic model can be used with **any confidence** to estimate the design flows considering these **substantial** and **variable** hydrological model output modifiers.

No factoring has been applied to the 2011 hydrologic model output. Sensitivity analysis of the impact of factoring the 1976 and 1996 hydrologic model on the levels predicted by the hydraulic model was undertaken:

"*The modelling shows that the DPIE* ***factoring of the flows for the 1996 event raises levels by approximately 50-200 mm across the study area****. The comparison to the recorded flood levels shows the calibration is similar with* ***the unfactored flows producing a closer match to the recorded flood levels****, and recorded gauge levels. Therefore, without factoring the comparison to gauge level and recorded flood heights is considered improved in the flood study area. It is noted that the extent of inundation is smaller than the factored flows model and compares closer to the aerial image of the 1996 flood event.* ***Calibration of the model is considered acceptable with or without the factoring of flows****. Therefore, the calibration of the sub model is not sensitive to the factoring applied to the 1976 and 1996 DPIE hydraulic model flows."* (p. 55, FFJV's Report)

Note that the surface level of the floodplain south of Goondiwindi gauge is about 216 m AHD. As the unfactored flow level for the 1996 model is 218.38 m AHD (Table 7.16), flood depths of 2.38 m are predicted. Changes of 50 – 200 mm are therefore on the order of ~10%. This variable application of a hydrological model output factor (no factor, +20%, or +60%) to the historical hydraulic model calibration events means it is unclear how consistency of an appropriate scaling factor for the design events could be achieved. Furthermore, the impact of changes to this parameter **(50 to 200 mm in flood levels) is not an insignificant change** with regards to potential impact on the Landholders.

5.3. Problems with the Hydraulic Model

We note that there is no consideration of rainfall that falls within the hydraulic model domain.

We note that minor hydraulic structures are not included in the model (p. 84, FFJV's Report).

In §9.4.2. of FFJV's Report reducing grid size from 30m to 15 m results in drops of water levels for the 1% AEP event of 50 mm throughout the model but 150 mm around the proposal corridor. Although afflux is minimally impacted when comparing existing to developed where both have 15 m grid. Considering the greater impact near the proposal corridor, this suggests a finer grid domain should be used at least in this region.

Table 9.15 from FFJV's Report compares predicted culvert velocities for a sub-model at grid sizes of 30 m and 5 m, as well as at different n-values. There are **substantial** changes in velocity, which brings to light that the model grid is too coarse in the vicinity of the culverts and that this may be impacting accurate prediction of their capacity in the 30 m grid model relied upon throughout. It is necessary to have a finer grid spacing in the vicinity of entrances and exits of 1d structures.

6. FLOOD FREQUENCY ANALYSIS

A flood frequency analysis was conducted by FFJV to estimate the predicted frequency of historical storm events.

Sections 8.2.3.1 and 8.2.3.2 of FFJV's Report describe the uncertainty and challenges of obtaining flows from the water surface levels measured at the gauges. While the in-bank ratings curves are excellent, that is of little utility for the kinds of floods relevant to inform the design of NS2B. There also appears to be uncertainty as to whether the flows derived from the ratings curves represent flow in the immediate vicinity of the gauge, or whether they also incorporate the break-out flows that join other watercourses (such as Morella Watercourse and Whalan Creek). For the Boggabilla ratings curve, the out of bank flows are strongly influenced by measured flows from the 1996 event that consider break-out:

"*The high-flow section of the current rating is strongly influenced by four flow measurements obtained during the 1996 flood, the highest three of which include an estimate of the breakout flows. The current rating should therefore be considered to give the total flow arriving upstream of Boggabilla, rather than the remaining flow in the Macintyre River at the actual gauge location downstream of Boggabilla.*" (p. 72, FFJV's Report)

It is not clear where the flow values for this gauge have been taken from (i.e., historical gaugings that poorly represent breakout, or if the ratings from the 1996 event are applied to earlier levels, etc):

"*The gauge rating has been updated on numerous occasions (WaterNSW website lists 79 historical tables; current table No. 153 dated from 14/01/2011). Additionally, it is understood that the Boggabilla gauge site has physically changed locations on several occasions, including in response to the construction of the Boggabilla Weir. The gauged flow points in Figure 8.6 show the recorded points for all locations with the current rating. No work to assess the rating quality or re-rate historical measurements has been undertaken.*" (p. 72, FFJV's Report)

For the Goondiwindi gauge, there is no reliable gauging data to derive a ratings curve for flows that break the banks:

"*The gauged level ratio of 94 per cent would ordinarily be considered as excellent. However, as shown in Figure 8.8, the level of the highest gauging is just below the surrounding floodplain level. The projection of the rating to higher levels/flows is therefore considered to be highly uncertain. Examination of the flood frequency analysis results discussed below and the TUFLOW hydraulic model calibration suggests that the rating does not reliably represent the flow conveyed in the floodplain.*"(p. 74, FFJV's Report)

It is also noted that the estimate of flow at Boggabilla for historical events is highly uncertain. It is not known whether the rating represents breakout flow:

"…For example, the 1976 flood of record has been estimated to have a peak varying flow from 2,760 m³/s (LT 2007) and 5,500 m³/s (LT 2004).

Another significant complication is whether the flow lost from the system into Whalan Creek and other breakouts upstream of the gauge location during high flow events has been included. FFA should ideally be conducted on the total catchment flow, as 'lost' flow above a threshold would lead to discontinuities in the relationship (see discussion below). It is unknown whether the previous studies report total flow or flow at the gauge." (p. 75, FFJV's Report)

We note a minor error in Figure 8.3 where the 1976 flow at this gauge is incorrectly plotted at ~2500 m^3/s where it is actually the highest flow ever recorded at this site (the point at ~50 yr ARI with flow of 5687 m^3/s). There is a similar error in Figure 8.2 where the 1976 flow is shown at ~1000 m^3/s and 50 y ARI, where it is also the largest flood on record at this site with flow of 1600 m^3/s and estimated ARI of ~60 y.

This highlights that the available gauged flow data is inherently uncertain, and particularly uncertain for the large break-out flows of relevance to the NS2B design.

7. SCALING OF DESIGN STORMS TO MATCH BOGGABILLA GAUGE

The design storm flows predicted by the hydrologic models have been scaled by a factor of 70% to better match the flows predicted at Boggabilla gauge by the flood frequency analysis:

"*8.2.4 Design flows based on flood frequency analysis*

Preliminary results from the Design Event Analysis predicted flows significantly higher than what was expected for the 1% AEP flood event, (3,800 m3/s) based on the FFA assessment at the Boggabilla Gauge. This is due to the inherent assumption in Design Event Analysis that the entire catchment will experience rainfall of the same magnitude. In a catchment like the Border Rivers, there are several major catchments that meet upstream of the study corridor. In an actual rainfall event it is highly unlikely that all catchments will experience the same AEP flood event, which is seen by the results of the FFA analysis. To account for this phenomenon, a factor has been applied to the four major inflows , Macintyre River, Dumaresq River, Macintyre Brook and Ottleys Creek. This factor was selected through iterations to achieve reasonable agreement with the 1% AEP flows in accordance with the FFA, with an uniform factor of 0.7 adopted for all inflows. In the absence of a full joint probability assessment, this approach was considered appropriate for the level of design currently being undertaken. FFJV comment that at Detailed Design joint probability analysis will be considered. It is noted however as the base data (Boggabilla gauge) for reconciling flows will be the same, the assessment is not expected to produce significantly different flows. In addition, it is noted a large change in flows in the Macintyre River catchment results in a relatively small change in flood levels in the vicinity of the proposal alignment (Water Technology 2016)." (p. 78, FFJV's Report)

This is claimed to be reasonable because a whole catchment is unlikely to experience the same frequency rainfall event. **We reject this approach** as:

1. The spatial non-uniformity of rainfall event frequency is already considered through the use of areal reduction factors when determining the design rainfall, and
2. The ratings curve at Boggabilla is not able to accurately convert elevations of water to whole-of-floodplain flow due to the complexity of breakout flows. It is particularly (and inherently) inaccurate for the less frequent events of relevance to design of NS2B.

8. ACCEPTABLE AFFLUX

SEARs 8.1(e) deals with the need for acceptable afflux guidelines. It does not prescribe what they should be, but does state they should be justified.

FFJV state that Table 4.2's Flood impact objectives are used as "guidance" and that they will ultimately be determined by interaction with landowners about what is an "acceptable impact" to the landowner. We have discussed these impacts with the Landholders and they want the 1976 flood impacts to be used; they also do not want such large affluxes, high velocities, scour and narrow openings which they are firmly convinced will have a significant impact on livestock and their property.

The BRVFMP states that affluxes in excess of 200 mm are unacceptable.

The BMT Report at p.4 expresses concern that *"Impacts of up to 400 mm on agricultural/grazing land and roads may also be **significant**.*"

The afflux levels and drainage structures shown in **Figure 2** were sourced from Figure A26 of FFJV's Report. **Figure 2** shows that A Mackay, R Mackay and RA & JA Doyle are impacted by an afflux greater than 200 mm and A Mackay and R Mackay are impacted by an afflux greater than 500 mm. This amount of afflux is **significant** in BMT's opinion. It is **unacceptable** under the BRVFMP and is **unacceptable** to the Landholders.

ARR2019 Book 1 Scope and Philosophy, p.132 states:

"*Flooding in agricultural regions can have concerns for crops, livestock and infrastructure… Livestock may be lost if unable to be relocated to areas outside flood limits.*

"*In order to determine appropriate risk mitigation measures for agriculture**, the specific implications for livestock** and crops **need to be considered**, and the risk assessment will need to incorporate these factors. In addition, agricultural infrastructure such as irrigation pipes, fences, buildings and machinery may be damaged and these can have significant value."*

The Landholders set out **specific implications for livestock** on page 2 of Annexure 1:

"*p. In the past a 1976 scale flood would overtop the old rail line which allowed livestock to not only seek refuge on top of the track but to continue further west looking for high ground. Many have survived by being washed down the Whalan Creek as far as the Newell Hwy. The proposed embankment at 3-7m in the air and fully fenced eliminates that survival option for livestock trapped on the south eastern side of the track. Up to 1000 head of weaner cattle can be in the afflux area of the track at any one time depending on seasonal conditions. ARTC's own hydrology predicts depths of up to 2m in this area, which would result in a catastrophic loss of livestock. This area is most certainly a sensitive receptor and we find this situation completely unacceptable.*

r. The modelled afflux for a 1976 event is unacceptable for landholders as the large area and increased period of inundation will lead to serious and irreversible damage to the structure and health of the soil inundated and substantially effect its productivity and the profitability of the agricultural enterprises on the land.

s. Landholders base impacts on a 1976 event and do not accept ARTC's approach to mitigating afflux through compensation." (p.2 **Annexure 1**)

The "acceptable" afflux as defined in the EIS is not appropriately justified and is not accepted by the Landholders in the vicinity of the NS2B alignment.

The BRVFMP, ARR2019 and the Landholders Concerns all uphold that the affluxes modelled by FFJV for the 1976 flood are unacceptable. Prior to the approval of the NS2B EIS the impacts as outlined by the Landholders should be used to inform the design to reduce the afflux to acceptable levels for the 1976 flood event.

9. POTENTIAL FOR SCOURING OF FLOODPLAIN SOILS

In FFJV's Report at p.103 it is mentioned that "*the velocities predicted from the 5 m grid model at the boundary are generally less than 0.5 m/s in both the existing no scour protection and with scour protection, and less than 0.4 m/s with the increased roughness, which is the allowable velocity for bare soil as per the maximum permissible velocities from the Border Rivers FPMP. (Table 1.1 BRVFMP 2018).*"

FFJV and the BRVFMP declare that velocities greater than 0.4 m/s may lead to scour of the soils. FFJV have provided no figure of developed case velocities. The existing case velocities of the 1% event in Figure A8-C (FFJV's Report) seem to mostly be below 0.5 m/s outside of the defined channels. Figure A15-B-2 (FFJV's Report) shows the predicted change in peak velocity due to development, showing mostly no change except for near chainage 25 km, where there is a region where velocities increase by >0.5 m/s extending up to 500 m from the railway embankment. This could well lead to localised scour and deposition in this region.

Figure A14-B-3 (FFJV's Report) suggests there is insufficient capacity around chainage 20 km (immediately downstream of ridgeline near Oakhurst road that is a natural southern limit for floodplain flow), 25 km (unnamed tributary draining to Whalan Creek) and 30 km (Whalan Creek), as evidenced by the significant afflux upstream and lower heights downstream. The impact at chainage 25 km is also clear on Figure A15-B-2 (FFJV's Report) where there are substantial drops in peak velocity upstream of the rail formation (due to damming) as well as on Figure A15-C-2 (FFJV's Report) by substantial increases in duration of inundation in the same area. This may lead to deposition of flood debris/silt, etc within this area impacting on land productivity; this possibility should be appropriately investigated considering SEARs 8.2(c):

"2. The Proponent must assess and model the pre-construction, during construction and operational impacts of the project on flood behaviour for a full range of flood events up to and including the probable maximum flood (including consideration of the impacts of climate change and differing storm durations). This will include:

…

(c) assessing any detrimental increases in the potential flood affectation, scouring or geomorphological changes to other properties, assets and infrastructure, over a full range of flood durations and flood frequencies;"

Similar impacts are seen for the 1 in 2,000 AEP, 1 in 10,000 AEP and the PMF events in Figures A16-E, A16-F and A16-G (FFJV's Report), respectively. It is particularly prominent between chainage 20 to 25 km.

These observations are listed on page 88 of FFJV's Report, but their significance is not adequately addressed.

Later sensitivity analysis using the 1976 flood flows (§9.4.8 FFJV's Report) shows a qualitatively similar picture for flood level impacts of the proposal (Figure A26 FFJV's Report).

We agree with BMT's statement on page 5 of the BMT Report that "*While flow hydrographs are presented in Figure 9.1 where the proposed embankment overtops (i.e. Ch 28.0 km to 28.5km),* ***consideration needs to be provided to other failure mechanisms*** *such as piping failure and the potential flood hazard to downstream sensitive receptors. As noted from Figure A16-E to A16-G a* ***significant head difference*** *would appear to be predicted in the location between chainage 20 km to 25 km.*"

It is SNW's view that these issues must not be put off to the detailed design stage and managed through individual landowner negotiations. A **proper design** needs to be put up for **assessment now as part of the EIS**. The design proposed in the EIS, and its impacts, are not acceptable to the Landholders.

10. GROUNDWATER

The SEARs specification for the Groundwater Hydrology is comprehensive, and the work that has been carried out by ARTC appears to address the requirements. Any potential impacts will only be short term, i.e. during the construction period.

Groundwater is a very important resource to the Landholders in this area, and it is therefore vital that any impacts be minimized so as not to cause any adverse impacts on the quality and volume of the resource relied on by farmers. A further consideration at the present time is the long-term drought that Inland NSW has suffered from for many years, which has put additional pressure on water resources, including groundwater.

There has been increased rain in recent months in Inland NSW, but it is understood that in the vicinity of the NS2B project there is still a rainfall deficit. The Bureau of Meteorology is forecasting higher than median rainfalls in this area over at least the next 4 months. This should assist in supplementing surface runoff, but there will be a lag before the groundwater aquifers will be recharged.

It is understood from EIS Chapter 14 that a groundwater level monitoring system has been installed throughout the NS2B area so that any impacts from the construction pumping can be identified. It suggests that if problems are identified, alternative water sources will be accessed in sequence. For this to work successfully, monitoring will have to be carried out on a timely basis (preferably by automatic gauges), with ARTC nominating a responsible entity, with an action plan if problems arise. This may have already been implemented.

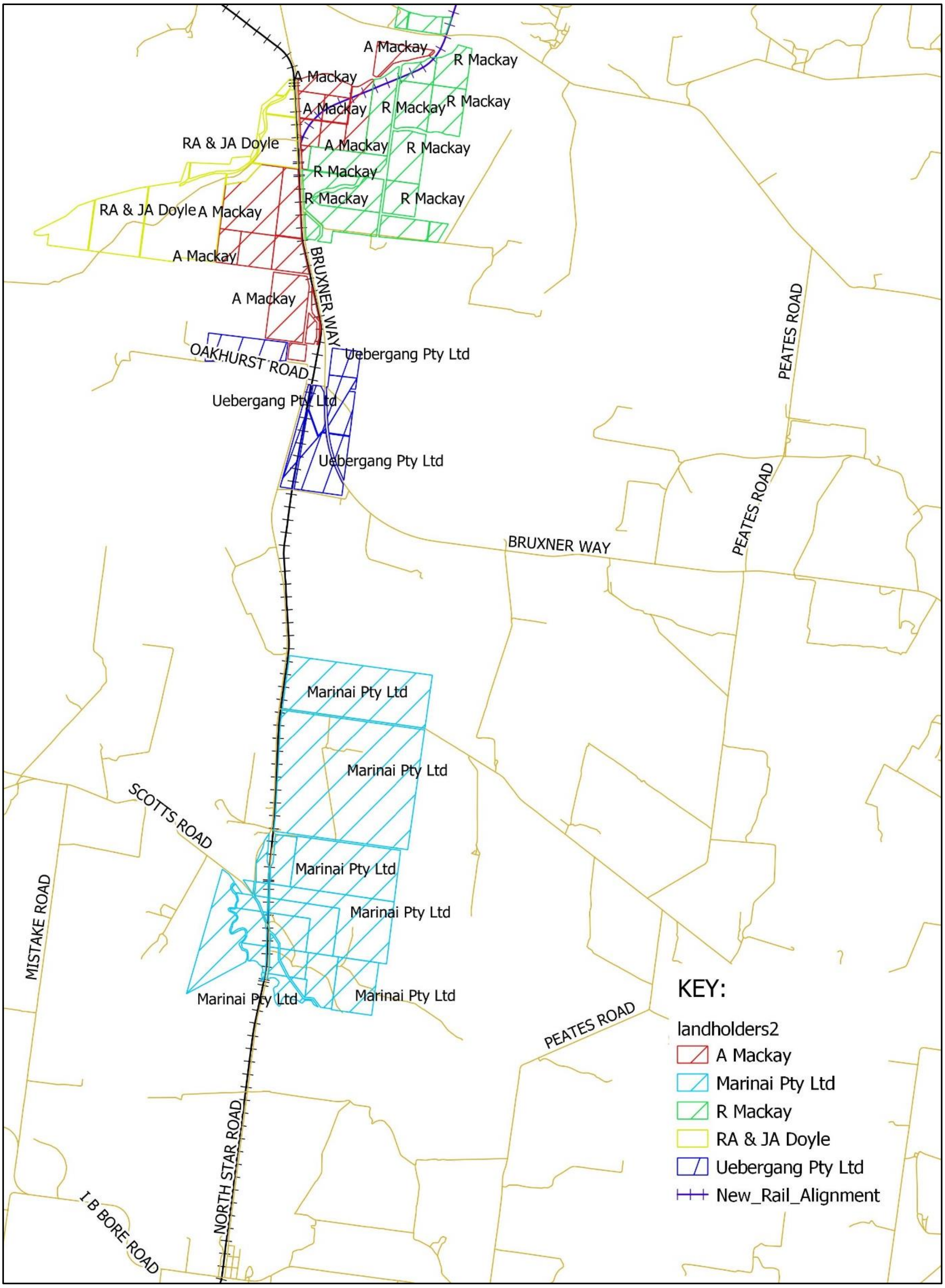

Figure 1: Landholders

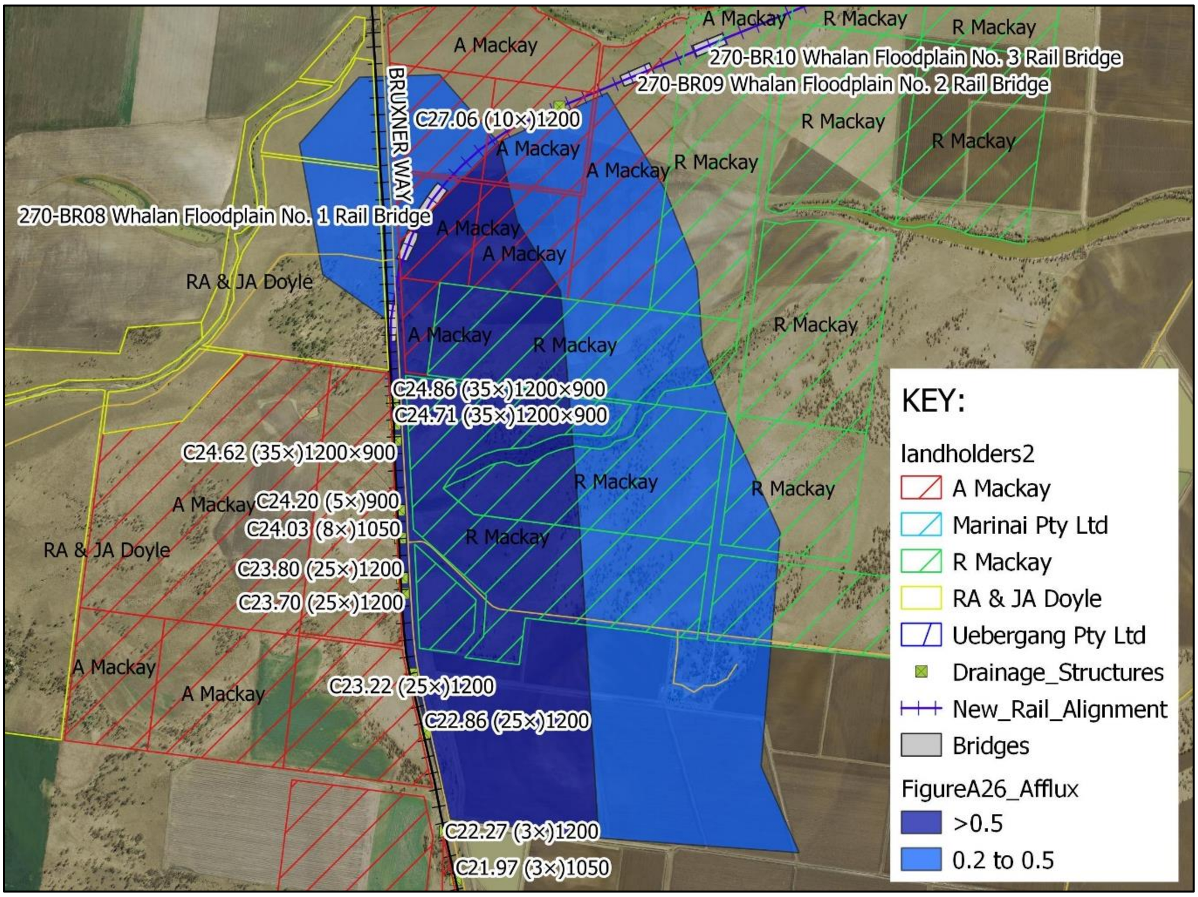

Figure 2: Modelled Afflux – 1976 Flood Event

DOCUMENTS RELIED ON

1. ARTC, North Star to NSW/Queensland Border Environmental Impact Statement, Chapter 13 – Surface Water and Hydrology, 17 August 2020 (“**EIS Chapter 13**”).
2. ARTC, North Star to NSW/Queensland Border Environmental Impact Statement, Chapter 14 – Groundwater, 17 August 2020 (“**EIS Chapter 14**”).
3. ARTC, North Star to NSW/Queensland Border Landholder/Stakeholder Questions – Feedback, 12 August 2020.
4. Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) Australian Rainfall and Runoff: A Guide to Flood Estimation, © Commonwealth of Australia (Geoscience Australia), 2019 (“**ARR2019**”).
5. BMT, Independent Hydrology & Flooding Review – North Star to NSW/QLD Border, Appendix H – Hydrology and Flooding Technical Report – Summary of Review Finding, 12 May 2020 (“**BMT Report**”).
6. FFJV, Appendix H – Hydrology and Flooding Technical Report, North Star to NSW/Queensland Border Environmental Impact Statement, Document No: 2-0001-270-EAP-10-RP-0407, Revision 3 (“**FFJV’s Report**”).
7. FFJV, Appendix N: Groundwater Technical Report, North Star to NSW/Queensland Border Environmental Impact Statement, Document 2-0001-270-EAP-10-RP-0408, Revision 0 (“**FFJV’s Groundwater Technical Report**”).

8. Markar, Sharmil, Millmerran Rail Group submission to the Senate inquiry into the management of the Inland Rail project by the Australian Rail Track Corporation and the Commonwealth Government, Management of the Inland Rail project by the Australian Rail Track Corporation and the Commonwealth Government, Submission 75, 29 November 2019.
9. NSW DPIE, Floodplain Management Plan for the Border Rivers Valley Floodplain (2020), Water Management Act, August 2020 ("**BRVFMP**")).
10. NSW DPIE, Secretary's Environmental Assessment Requirements, Inland Rail North Start to NSW/Queensland Border (SSI 18_9371), 13 March 2020 ("**SEARs**").

STEPHEN N WEBB & ASSOCIATES PTY LTD

Dr Stephen Webb

Director

Date: 19 October 2020

Ms Nicole Webb

Director

Date: 19 October 2020

Annexure 1: Landholders Concerns

The Landholders have numerous concerns regarding the NS2B Project and the explanations/justifications put forward in the EIS, including in relation to the flooding and hydrology. In particular:

1% AEP versus 1976 flood event

a. the ARTC have focussed on the 1% AEP as the flooding event they use to inform the reference design;
b. the 1% AEP prescribed under the SEARs seems inappropriate because the 1976 flood event was substantially greater than the 1% AEP;
c. a report prepared by BMT Commercial Australia Pty Ltd dated 12 May 2020 (**BMT Report**) indicated peak flow rates which are approximately 58% higher in 1976 when compared with the modelled flow rates for the 1% AEP;
d. the BMT Report also identified "*residual uncertainty*" of the modelled 1% AEP event due to the difficulty of extrapolating estimates of the breakout flows upstream of the Boggabilla flood gauge used to calibrate the model;
e. the reference design for bridges across the floodplain show a variance in flood height for a 1% AEP and a 1976 scale event to be almost 1 metre, a substantial increase in volume right across the floodplain; and
f. the 1976 flood event is the largest in living memory and is the benchmark that has been adopted by the local community. For example, we understand that Goondiwindi Regional Council has used the 1976 event as a reference for hydrological modelling used for the region. Many local landholders also have direct experience of the 1976 event and are not comfortable with the use of a substantially lesser flow to determine development in the valley.

Modelling peak flow rates for a 1976 flood event versus actual estimated flows upstream

g. Eddie Billing is a landholder upstream of the junction of the Dumeresq River and Macintryre River and of the proposed NS2B alignment (D1). We are instructed that Mr Billing provides detailed information during flooding events and is often requested to provide this information to Goondiwindi Regional Council and other agencies including the State Emergency Services and the Bureau of Meteorology. Mr Billing providing the ARTC with flood data in May 2019, including flood heights and flow rates recorded by him and by the NSW and QLD departments for a range of flood events, including the 1976, 1996 and 2011 events.
h. The recorded peak flow rates determined for three gauges upstream of the junction of the rivers at Inglewood, Bonshaw and Yetman, when adjusted for unrecorded flows from Ottleys Creek and local runoff, suggest a substantially higher peak flow than the modelled 745,000ML/day. The actual recorded flow rates suggest a combined flow rate of closer to 1,000,000 ML/day, which is 34% higher than estimated in the ARTC's model.
i. We are instructed that the ARTC have since dismissed this variance suggesting that there is some doubt as to the estimated flow rates upstream and that flows will be lower due to attenuation on the floodplain. They used an averaging mechanism to base their assumptions for modelling purposes.
j. The Landholders remain concerned that the ARTC are significantly underestimating the 1976 event.

Projected afflux caused by the NS2B alignment

k. As noted earlier, the reference design is informed by the 1% AEP event.
l. The EIS identifies acceptable afflux ranges, although it is not clear to us whether these parameters are established by the SEARs.
m. The anticipated afflux is also modelled for a 1976 flood event.

n. The Landholders are concerned that the estimated afflux may be substantially underestimated due to low estimated flow rates for a 1976 event. In particular, the velocities through bridges and other structures as shown in the reference design may be excessive, particularly given the soil types in the floodplain, and will lead to scouring and erosion.
o. The excessive afflux indicated in a modelled 1976 scale event on the southern end of the floodplain from Wearne to the rail bridge over the Bruxner Highway indicates that there is insufficient bridging to reduce the extent of afflux to more acceptable levels.
p. In the past a 1976 scale flood would overtop the old rail line which allowed livestock to not only seek refuge on top of the track but to continue further west looking for high ground. Many have survived by being washed down the Whalan Creek as far as the Newell Hwy. The proposed embankment at 3-7m in the air and fully fenced eliminates that survival option for livestock trapped on the south eastern side of the track. Up to 1000 head of weaner cattle can be in the afflux area of the track at any one time depending on seasonal conditions. ARTC's own hydrology predicts depths of up to 2m in this area, which would result in a catastrophic loss of livestock. This area is most certainly a sensitive receptor and we find this situation completely unacceptable.
q. BMT, in their review of ARTC's modelled hydrology and hydraulic assumptions, qualify their support for the model and the 1% AEP as the basis for design and compensation for Landholders, and other matters, 16 times.
r. The modelled afflux for a 1976 event is unacceptable for landholders as the large area and increased period of inundation will lead to serious and irreversible damage to the structure and health of the soil inundated and substantially effect its productivity and the profitability of the agricultural enterprises on the land.
s. Landholders base impacts on a 1976 event and do not accept ARTC's approach to mitigating afflux through compensation.

Scouring and erosion

t. The ARTC purport that there will be no net change in velocity of flood waters as a result of construction of an embankment across the floodplain.
u. The Landholders fail to see how the construction of an embankment 3-7m high, with only periodic drainage, will not create additional velocity along the embankment and consequent scouring and erosion.
v. To date, the Landholders have been provided no detail justifying the predicted impacts (or lack of impacts) modelled by the ARTC.
w. The Landholders also do not believe the erosive nature of the black vertisol soils on the floodplain, which are particularly susceptible to damage from erosion, have been adequately considered in the reference design.