# Memorandum

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FROM: Ella Harrison
DATE: 11 May 2018
SUBJECT: North Byron FRMS&P – Initial and Continuing Loss Sensitivity Test
PROJECT NUMBER: 117098

## 1. INTRODUCTION

As part of the peer review undertaken by WMA Water (March 2018) of the hydrologic model developed by BMT WBM for the North Byron Shire Flood Study (2016), it was identified that a review of the initial and continuing losses would be undertaken.

The Initial Loss (IL) parameter represents the loss of rainfall prior to the commencement of surface runoff. It is related to land type (e.g. urban, rural topography) and is used to represent antecedent conditions. The Continuing Loss (CL) represents the average loss rate during the remainder of the storm.

In the North Byron Shire Flood Study, the Forested area IL values adopted for design events were significantly lower than those used in calibration events, and are also considered low compared to ARR2016 recommended median values. The CL adopted in the Flood Study are also high compared to ARR recommendations. Table 1 below summaries the variables used.

**Table 1: Initial loss adopted for calibration and design events**

| Ground cover | Initial Loss (mm) | | | Continuing Loss (mm/hr) | | |
|---|---|---|---|---|---|---|
| | Calibration events | Design Events | ARR Recommended Median Values | Calibration events | Design Events | ARR Recommended Median Values |
| **Urban** | 0 | 0 | 38 (*ARR2016*)<br>10 to 35 (*ARR1987*) | 1 | 1 | 2.5 (*ARR2016 and ARR1987*) |
| **Rural** | 30 (*May 1987*)<br>15 (*June 2005*)<br>5 (*Jan. 2012*) | 5 | | 4 | 4 | |
| **Forested** | 100 (*June 2005, May 1987*)<br>80 (*Jan. 2012*) | 20 | | 6 | 6 | |

28% of the total catchment area is classed as 'forested; land use, located mainly in the upper Brunswick River catchment. Thus, Forested IL and CL values may have an impact on modelled flows in upper Brunswick River localities such as Main Arm and Mullumbimby. Sensitivity analysis on this value has been undertaken to determine the influence it may have on the resulting flows.

This memo presents the findings of the sensitivity analysis on the IL and CL values of the XP-RAFTS hydrologic model. Four different IL values were studied: 20, 40, 80 and 100 mm. Three different CL values were studied: 4, 5 and 6 mm/hr. Results are analysed for the 20% AEP, 1% AEP and PMF design flood events.

# 2. INITIAL LOSS SENSITIVITY ANALYSIS

## 2.1. 1% AEP DESIGN EVENT

Table 2 and Figure 1 show the modelled flow at various locations in the catchment, for the four IL scenarios, for the 1% AEP design event.

Adjustment to the 'forested' IL value has a significative impact on Brunswick River flow. At Durrumbul, flow varies from 440$m^3$/s to 740 $m^3$/s depending on IL. It corresponds to a flow increase of 41% for an IL value decrease from 100mm to 20mm. A similar difference is calculated at Federation Bridge in Mullumbimby (730$m^3$/s to 1140 $m^3$/s, 36%) and on Brunswick Mouth (830$m^3$/s to 1250 $m^3$/s, +34%).

The impact is less for Marshalls Creek (±40$m^3$/s, 12% difference at Billinudgel) and for Yelgun Creek (±30$m^3$/s, 27% difference at Kallaroo Circuit). There is no impact on Simpsons Creek flow as the catchment is almost exclusively classed as Rural.

Forested IL values have an important impact on Brunswick River modelled flow that lead to a reduction of 420$m^3$/s for the 1% AEP design event.

**Table 2: Impact of Initial Loss values on 1%AEP Flow for different location**

| 1% AEP Flow ($m^3$/s) | Forested IL 20 | Forested IL 40 | Forested IL 80 | Forested IL 100 |
|---|---|---|---|---|
| **Durrumbul Gauge (Brunswick River)** | 740 | 670 | 520 | 440 |
| **Federation Bridge (Brunswick River)** | 1140 | 1060 | 840 | 730 |
| **Brunswick Head (Brunswick River)** | 1250 | 1170 | 950 | 830 |
| **Billinudgel (Marshalls Creek)** | 360 | 350 | 330 | 320 |
| **Kallaroo Circuit (Yelgun Creek)** | 110 | 110 | 90 | 80 |
| **Sth Beach Rd (Simpsons Creek)** | 520 | 520 | 520 | 520 |

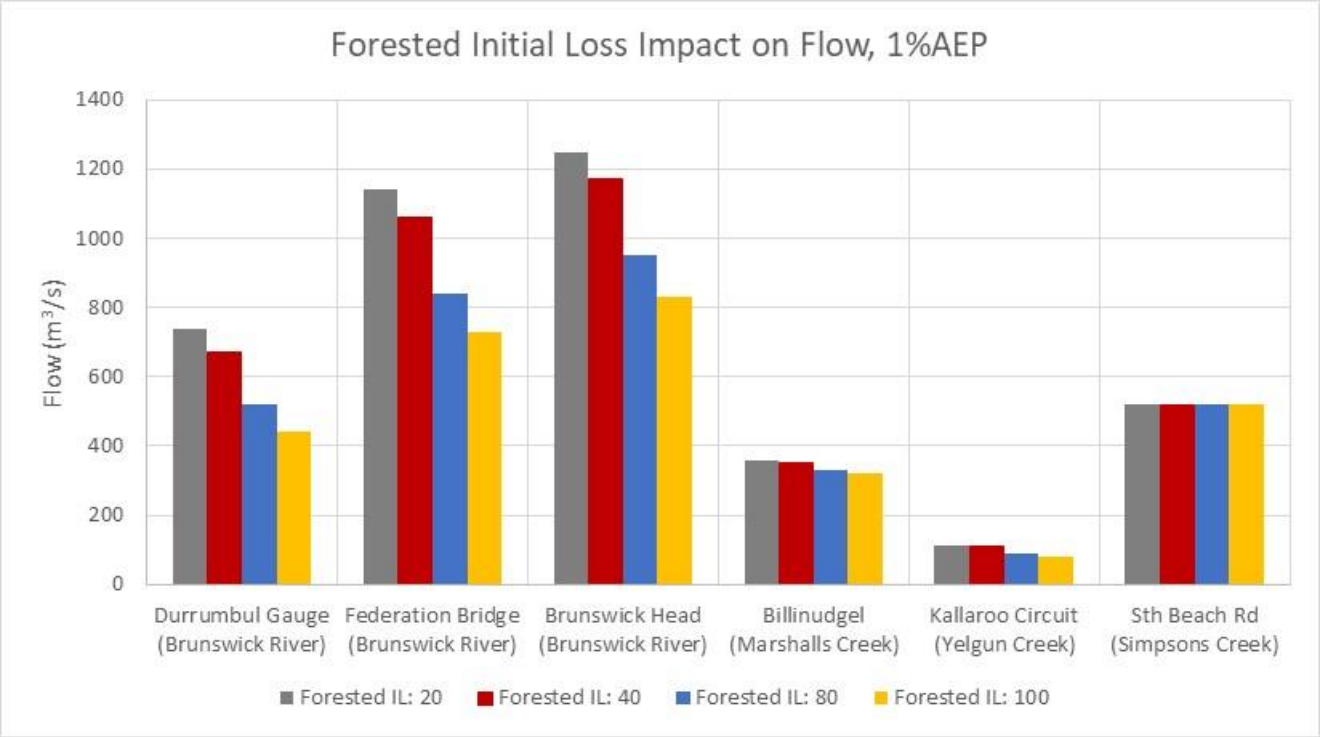


**Figure 1: Initial Loss Sensitivity Analysis, 1%AEP**

## 2.2. 20% AEP DESIGN EVENT

For the 20% AEP design event, the impact on flow is still substantial in the Brunswick River. Flow varies from 170m$^3$/s to 280m$^3$/s at Durrumbul.

Similar to the 1% AEP event, flow is less sensitive to IL changes for Marshalls Creek and Yelgun Creek and is non-existent for Simpsons Creek.

**Table 3: Impact of Initial Loss values on 20%AEP Flow for different location**

| 5% AEP Flow (m$^3$/s) | Forested IL 20 | Forested IL 40 | Forested IL 80 | Forested IL 100 |
|---|---|---|---|---|
| **Durrumbul Gauge (Brunswick River)** | 280 | 260 | 210 | 170 |
| **Federation Bridge (Brunswick River)** | 470 | 440 | 340 | 290 |
| **Brunswick Head (Brunswick River)** | 540 | 500 | 400 | 350 |
| **Billinudgel (Marshalls Creek)** | 170 | 170 | 150 | 150 |
| **Kallaroo Circuit (Yelgun Creek)** | 50 | 50 | 40 | 30 |
| **Sth Beach Rd (Simpsons Creek)** | 260 | 260 | 260 | 260 |

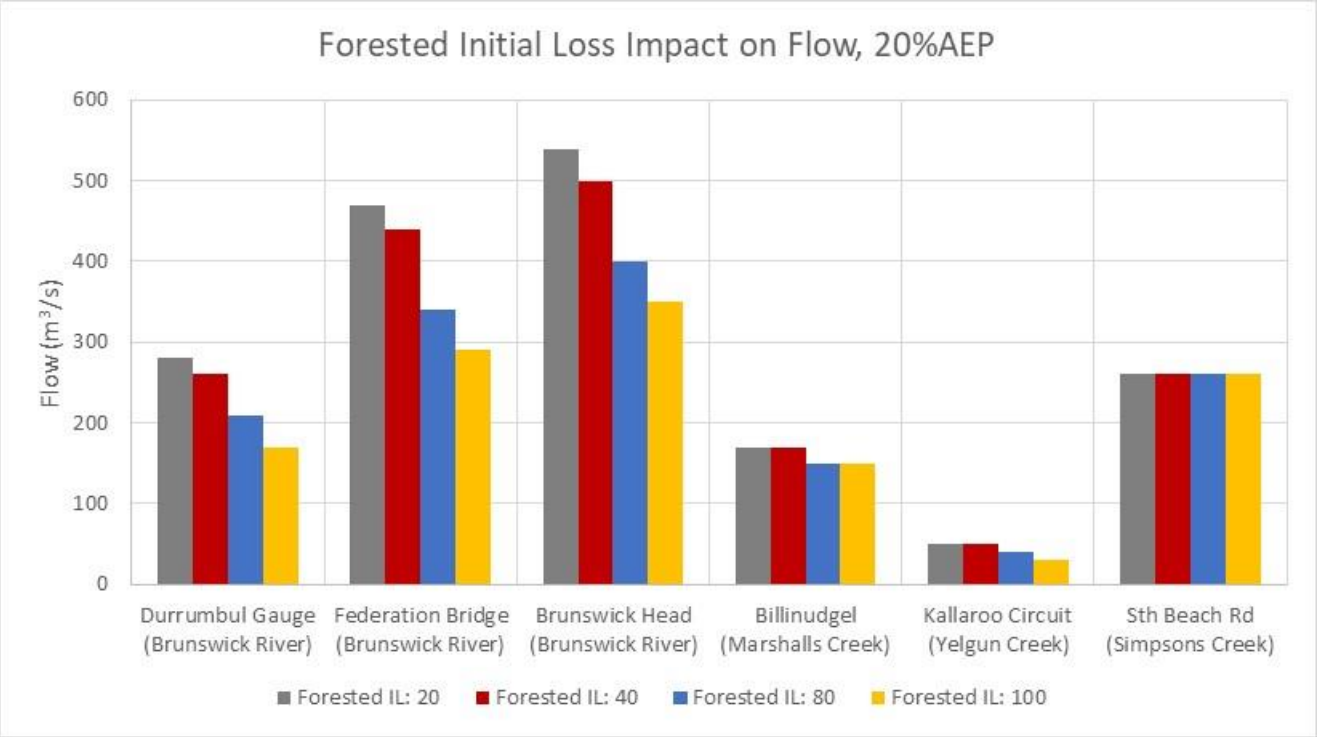


**Figure 2: Initial Loss Sensitivity Analysis, 20%AEP**

## 2.3. PMF DESIGN EVENT

For the PMF event, sensitivity tests show that whilst an IL value change can cause an increase of 250m$^3$/s on the downstream part of Brunswick River (Brunswick Head), this only represents 5% of the total flow. Thus, changes in IL values results in a less significant flow change (varying between 4750m$^3$/s and 5000m$^3$/s). There is almost no impact on Marshalls Creek and Yelgun Creek.

**Table 4: Impact of Initial Loss values on PMF Flow for different location**

| PMF AEP Flow (m$^3$/s) | Forested IL 20 | Forested IL 40 | Forested IL 80 | Forested IL 100 |
|---|---|---|---|---|
| **Durrumbul Gauge (Brunswick River)** | 2930 | 2910 | 2830 | 2780 |
| **Federation Bridge (Brunswick River)** | 4450 | 4440 | 4390 | 4360 |
| **Brunswick Head (Brunswick River)** | 5000 | 4960 | 4840 | 4750 |
| **Billinudgel (Marshalls Creek)** | 1510 | 1490 | 1460 | 1450 |
| **Kallaroo Circuit (Yelgun Creek)** | 470 | 460 | 440 | 420 |
| **Sth Beach Rd (Simpsons Creek)** | 2510 | 2510 | 2510 | 2510 |

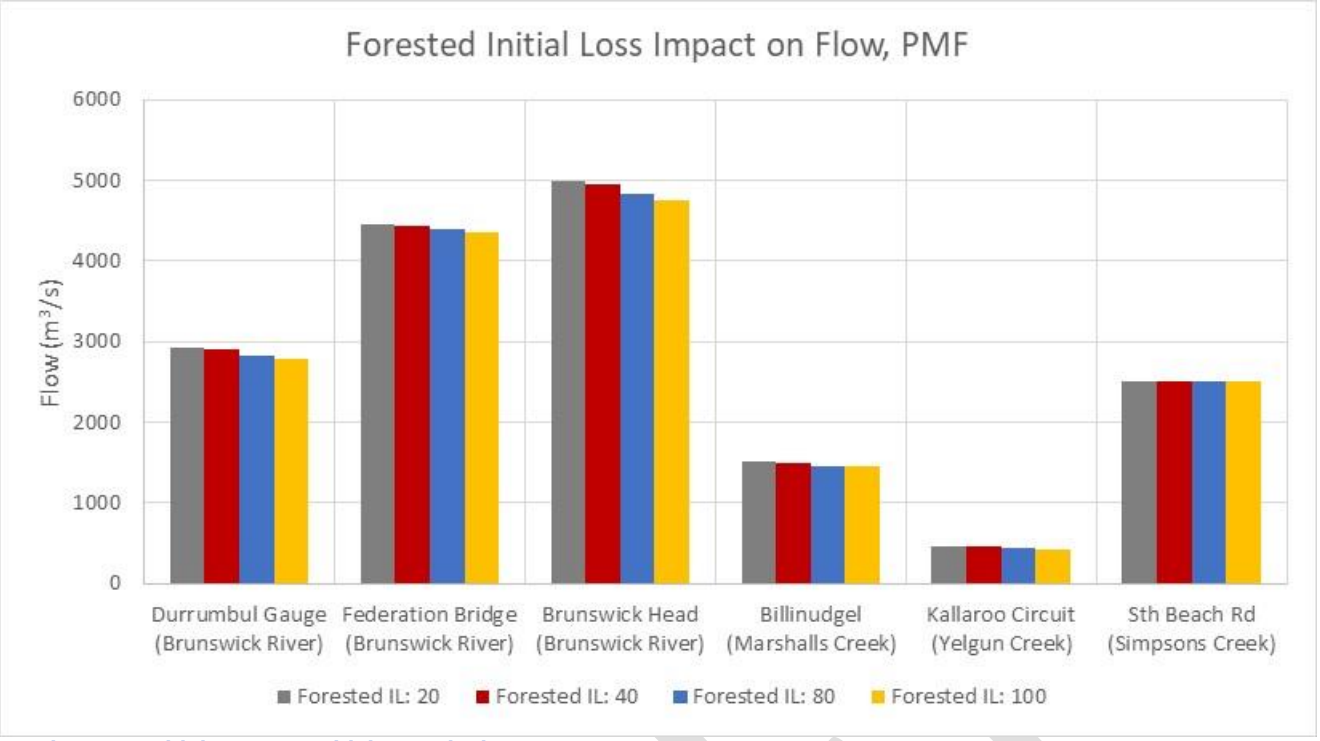


**Figure 3: Initial Loss Sensitivity Analysis, PMF**

# 3. CONTINUING LOSS SENSITIVITY ANALYSIS

## 3.1. 1% AEP DESIGN EVENT

Table 5 and Figure 4 show the modelled flow at various locations in the catchment, for the three CL scenarios, for the 1% AEP design event.

Adjustment to the Forested CL value doesn't have a significative impact on Brunswick River flow. At Durrumbul, flow varies from 670m$^3$/s to 690m$^3$/s depending on CL. It corresponds to a flow increase of only 3% between 6mm/hr and 4mm/hr. A similar difference is calculated at Federation Bridge in Mullumbimby (1060m$^3$/s to 1090m$^3$/s, 3%) and on Brunswick Mouth (1170m$^3$/s to 1200m$^3$/s, 3%).

The impact is zero for Marshalls Creek, Yelgun Creek and Simpsons Creek.

**Table 5: Impact of Continuing Loss values on 1%AEP Flow for different location**

| 1% AEP Flow (m$^3$/s) | Forested CL 4 mm/hr | Forested CL 5 mm/hr | Forested CL 6 mm/hr |
|---|---|---|---|
| **Durrumbul Gauge (Brunswick River)** | 690 | 680 | 670 |
| **Federation Bridge (Brunswick River)** | 1090 | 1080 | 1060 |
| **Brunswick Head (Brunswick River)** | 1200 | 1180 | 1170 |
| **Billinudgel (Marshalls Creek)** | 350 | 350 | 350 |
| **Kallaroo Circuit (Yelgun Creek)** | 110 | 110 | 110 |
| **Sth Beach Rd (Simpsons Creek)** | 520 | 520 | 520 |

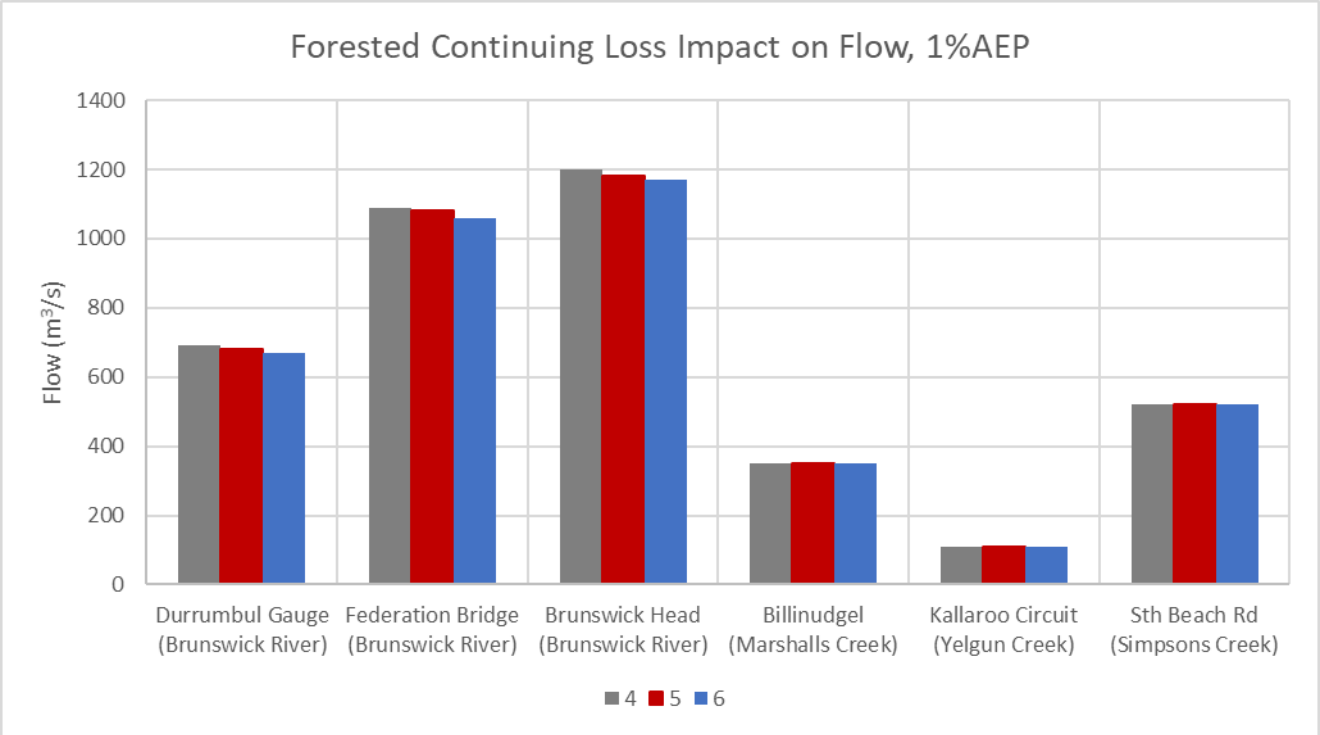


**Figure 4: Continuing Loss Sensitivity Analysis, 1%AEP**

## 3.2. 20% AEP DESIGN EVENT

For the 20% AEP design event, there is almost no impact on flow. The most important impact occurs at Durrumbul Gauge (260m$^3$/s to 270m$^3$/s, 4%).

**Table 6: Impact of Continuing Loss values on20%AEP Flow for different location**

| 5% AEP Flow (m$^3$/s) | Forested CL 4 mm/hr | Forested CL 5 mm/hr | Forested CL 6 mm/hr |
|---|---|---|---|
| **Durrumbul Gauge (Brunswick River)** | 270 | 270 | 260 |
| **Federation Bridge (Brunswick River)** | 450 | 440 | 440 |
| **Brunswick Head (Brunswick River)** | 510 | 500 | 500 |
| **Billinudgel (Marshalls Creek)** | 170 | 170 | 170 |
| **Kallaroo Circuit (Yelgun Creek)** | 50 | 50 | 50 |
| **Sth Beach Rd (Simpsons Creek)** | 260 | 260 | 260 |

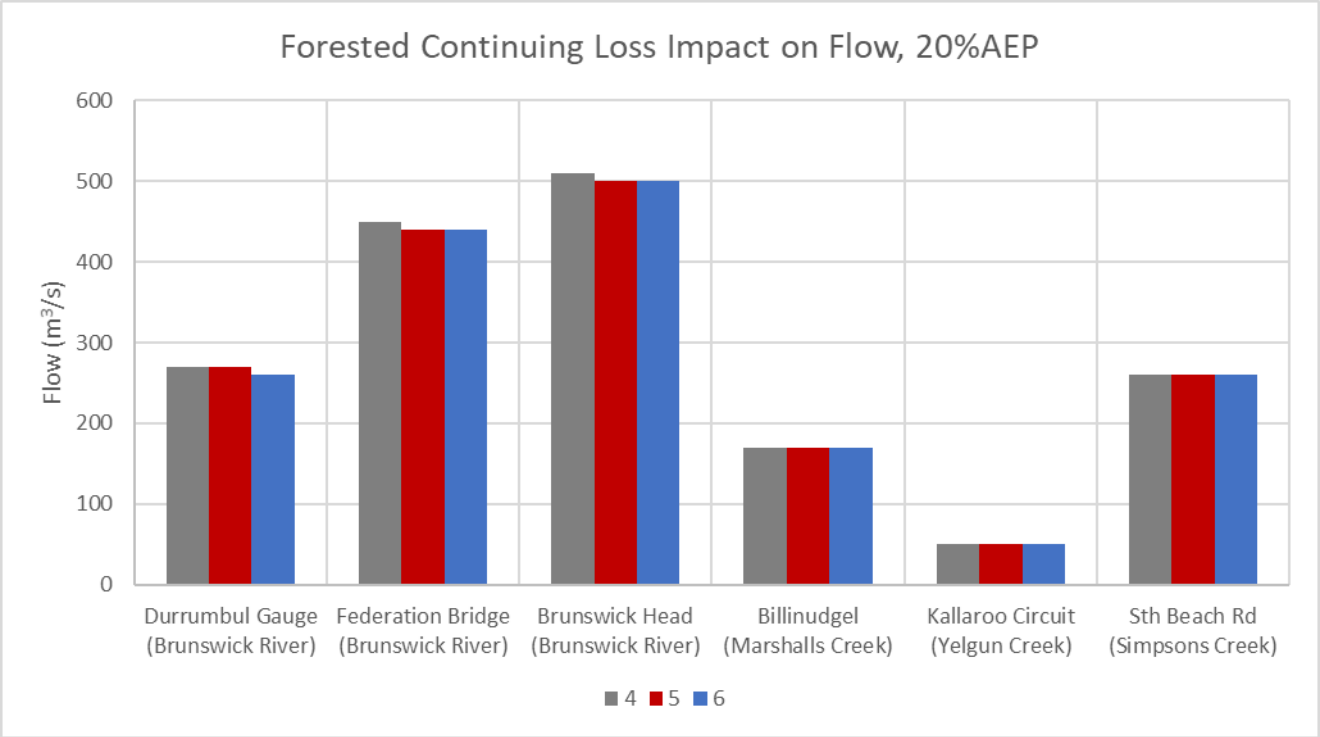


Figure 5: Continuing Loss Sensitivity Analysis, 20%AEP

## 3.3. PMF DESIGN EVENT

For the PMF, sensitivity tests show that a CL value change can cause an increase of only 20m$^3$/s on Brunswick River. It represents less than 1% of the total flow.

Table 7: Impact of Continuing Loss values on PMF Flow for different location

| PMF AEP Flow (m$^3$/s) | Forested CL 4 mm/hr | Forested CL 5 mm/hr | Forested CL 6 mm/hr |
|---|---|---|---|
| **Durrumbul Gauge (Brunswick River)** | 2930 | 2920 | 2910 |
| **Federation Bridge (Brunswick River)** | 4460 | 4450 | 4440 |
| **Brunswick Head (Brunswick River)** | 4980 | 4970 | 4960 |
| **Billinudgel (Marshalls Creek)** | 1500 | 1490 | 1490 |
| **Kallaroo Circuit (Yelgun Creek)** | 460 | 460 | 460 |
| **Sth Beach Rd (Simpsons Creek)** | 2510 | 2510 | 2510 |

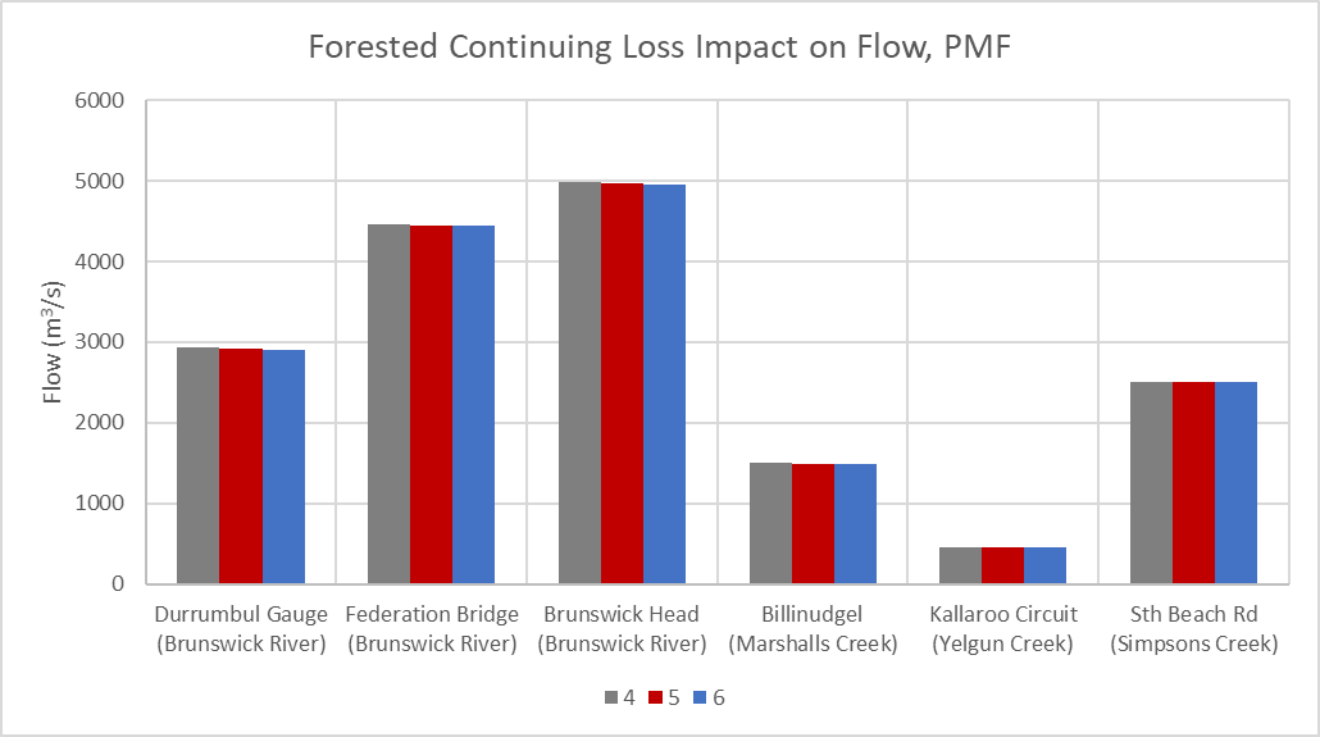


**Figure 6: Continuing Loss Sensitivity Analysis, PMF**

# 4. CONCLUSION

## 4.1. Initial Loss values

Sensitivity tests on the XP-RAFTS hydrologic model show that altering 'forested' IL value has a greater impact on the flows of smaller design events, than the larger more extreme events like the PMF. They also show that the impact is significant for Brunswick River as the majority of forested areas are located on upper Brunswick River catchment.

For the Brunswick River, an IL value decrease from 100mm to 20mm causes a 41% flow increase in Main Arm and 36% in Mullumbimby for the 1% AEP design event.

Forested IL adopted by BMT WBM for calibration and design events are significantly different. For calibration events, the IL values are often an artefact of limited rainfall temporal pattern data and the adopted high IL values may be compensating for rainfall data limitations. Thus, IL values adopted for the design events are lower to ensure an element of conservatism. However, the hydrologic model is particularly sensitive to changes in the 'forested' IL value especially in the Brunswick River. An IL value of 20mm is not only much lower than the calibration values (80mm and 100mm) but also lower than ARR2016 recommended value for the area (38mm). The heavily vegetated tropical nature of the vegetation in the North Byron catchment also suggests that the IL value should be higher.

It is recommended to use an IL value of 40mm for forested area for the design events. This value is still conservative regarding the adopted value for calibration events and is more consistent with the ARR2016 adopted value and the type of vegetation in the area.

## 4.2. Continuing Loss values

Sensitivity tests show that the 'forested' CL value does not have a significant impact on. A CL decrease from 6mm/hr to 4mm/hr only results in a 3% flow increase for the 1%AEP design event. As such, it is recommended that the CL vale is unchanged.

## List of Figures



## Reference

North Byron Shire Flood Study (BMT WBM, 2016)