

Scale: 1:5,000

50 0 50 100 150 m

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LEGEND

--- Two-Dimensional Model Boundary	Proposed Rail Works
--- Catchment Boundary	Airport North and Airport East Road Works
--- Existing Drainage System to Remain	Drainage Outlet Location and Identifier
--- Proposed Drainage System	Proposed Corridor Access Road
	Project Footprint

Botany Rail Duplication EIS

TECHNICAL WORKING PAPER: FLOODING

Figure B.20
(Sheet 3 of 3)

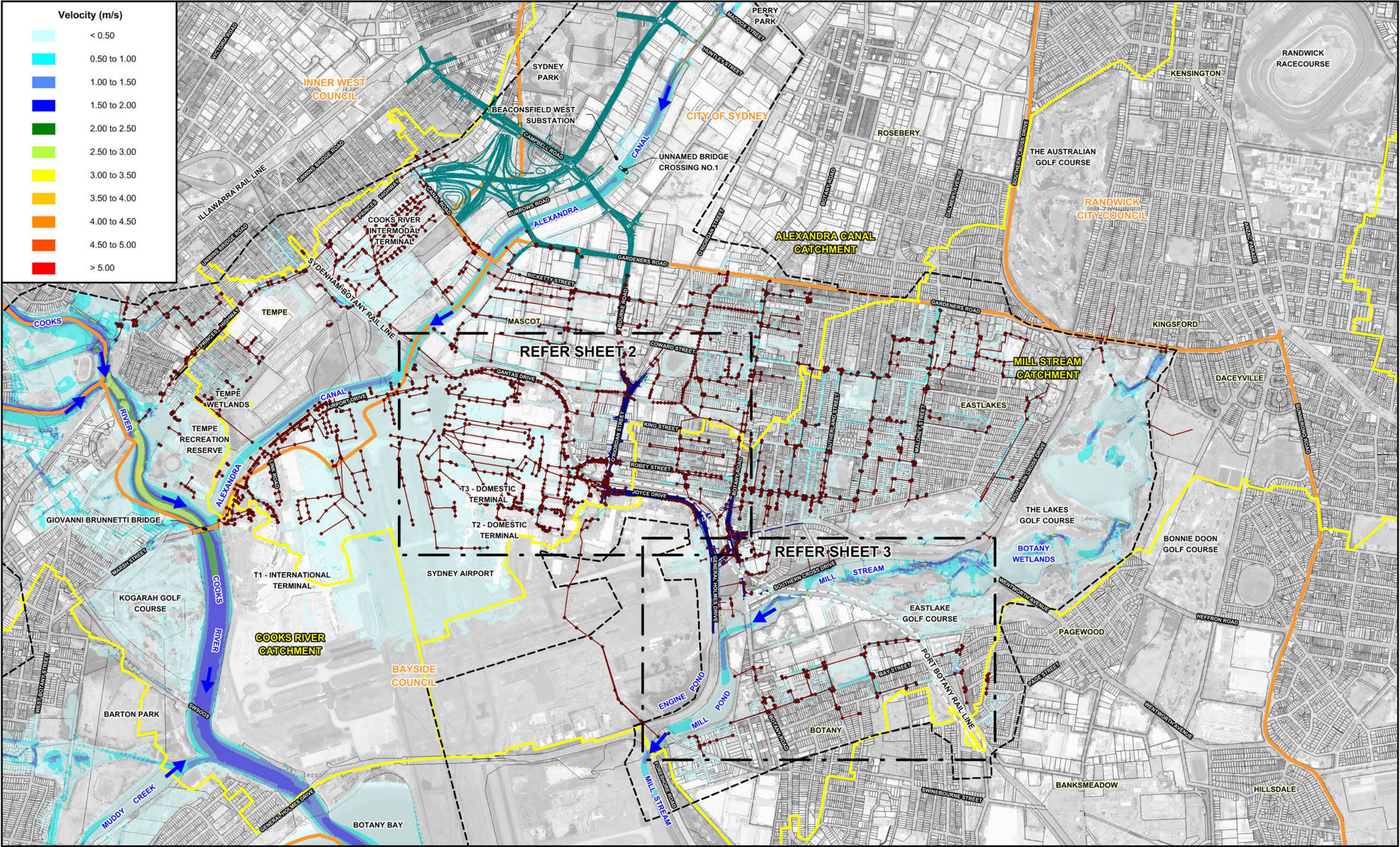
IMPACT OF PROJECT OPERATION ON PEAK FLOW VELOCITIES

10% AEP EVENT

Note:

The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 2m (min.) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.



Velocity (m/s)

< 0.50
0.50 to 1.00
1.00 to 1.50
1.50 to 2.00
2.00 to 2.50
2.50 to 3.00
3.00 to 3.50
3.50 to 4.00
4.00 to 4.50
4.50 to 5.00
> 5.00

LEGEND

Two-Dimensional Model Boundary	Project Footprint
LGA Boundary	Airport North and Airport East Road Works
Catchment Boundary	New M5 Surface Road Works
Existing Drainage System	

Scale: 1:20,000

200 0 200 400 600 m

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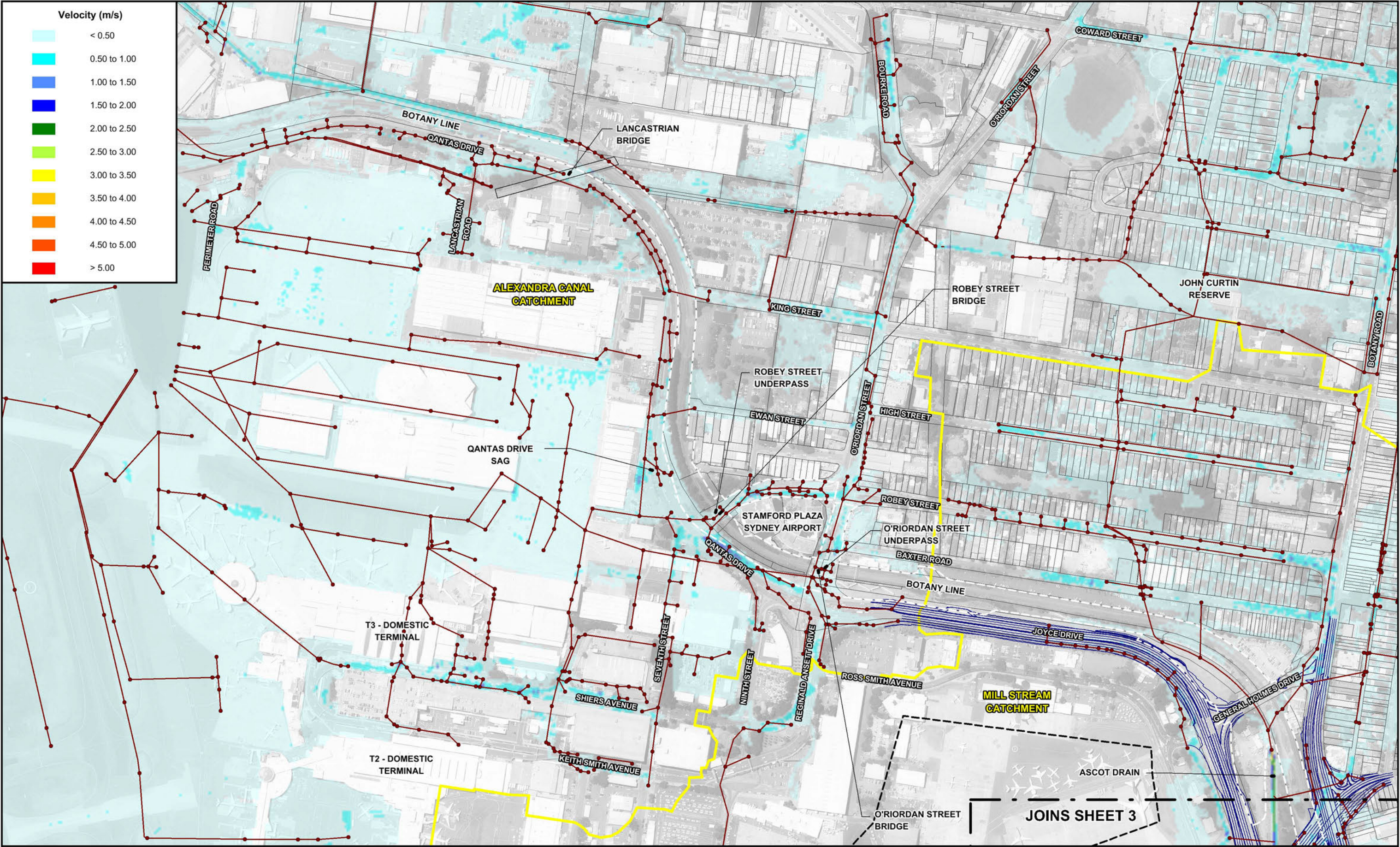
TECHNICAL WORKING PAPER: FLOODING

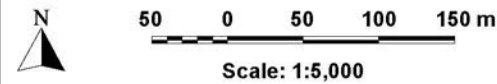
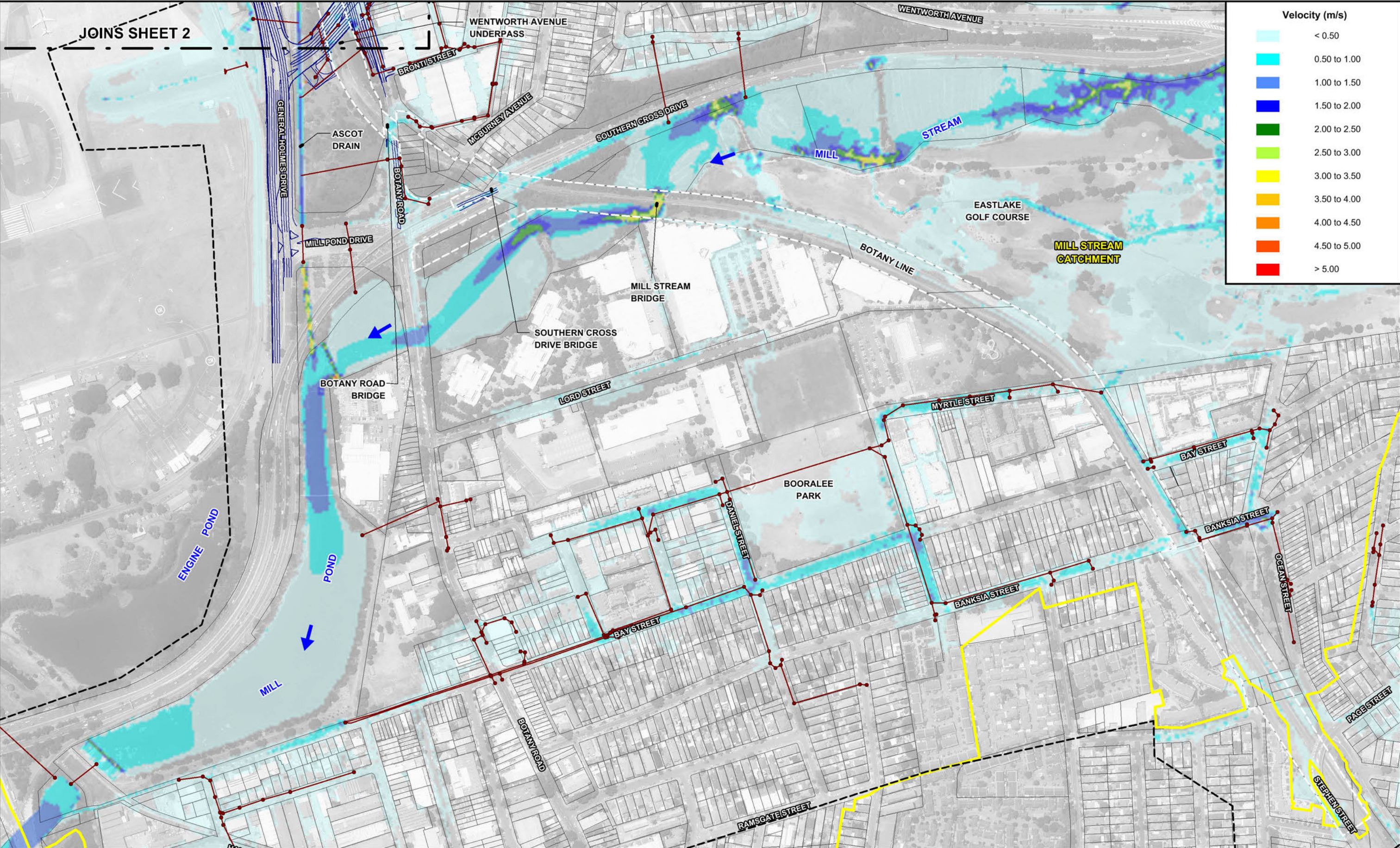
Figure B.21

(Sheet 1 of 3)

PEAK FLOW VELOCITIES

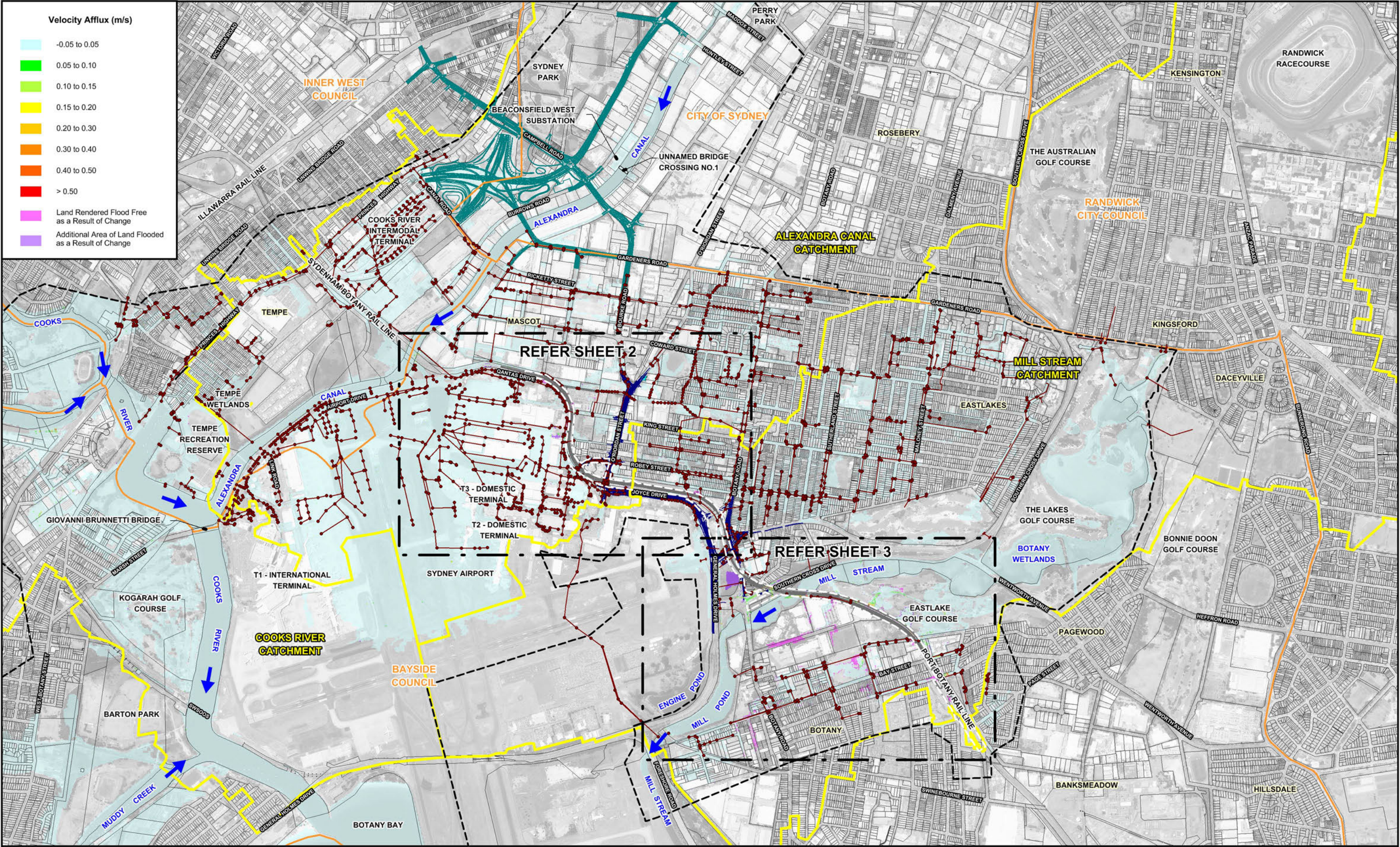
PRE-PROJECT CONDITIONS - 1% AEP EVENT

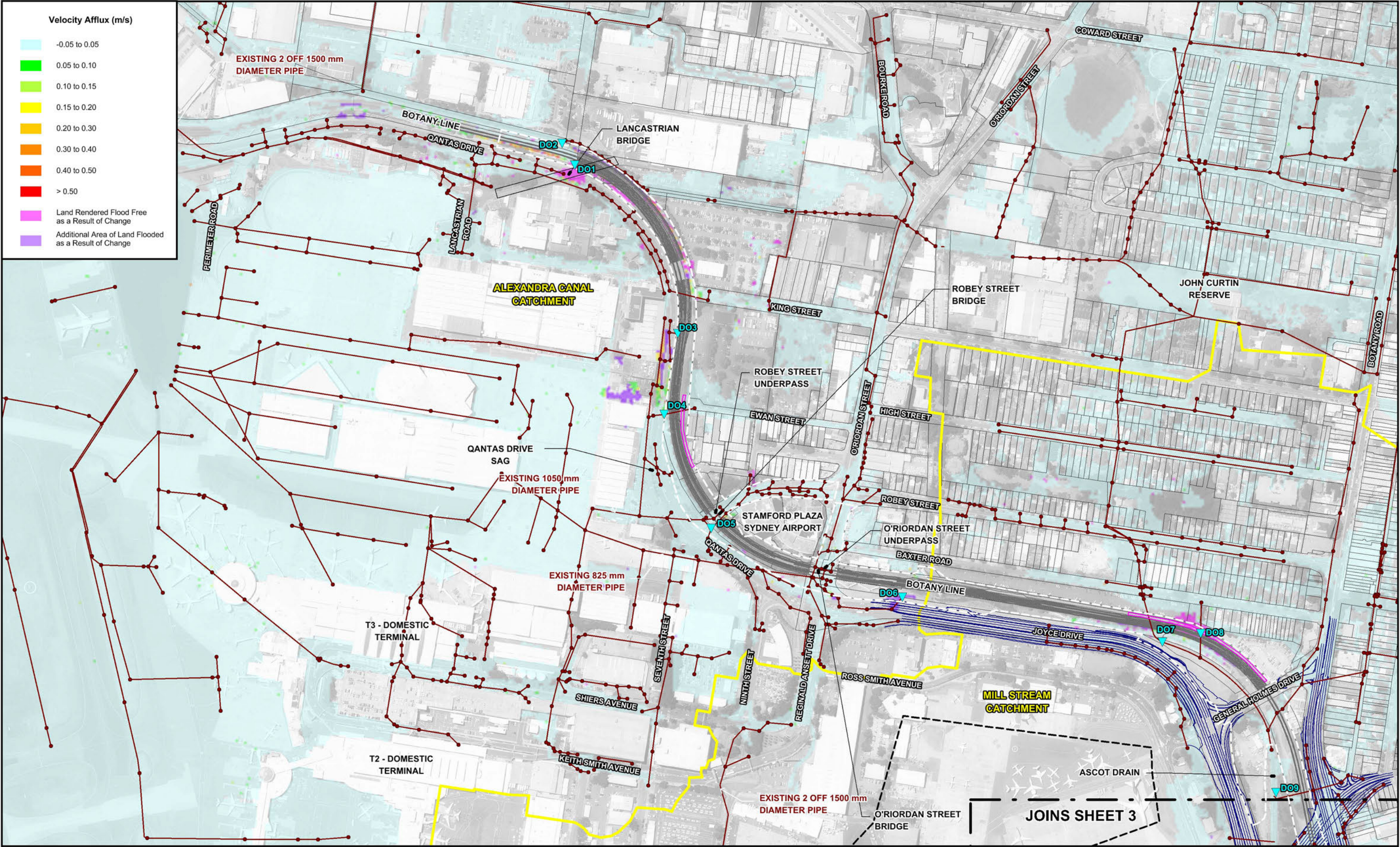


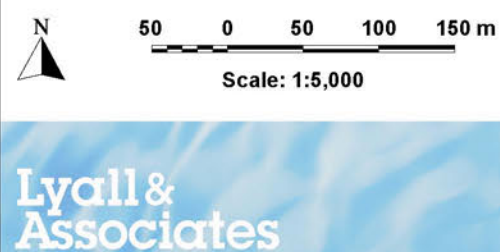
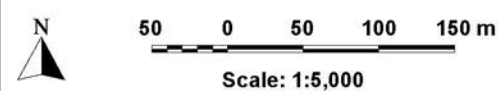
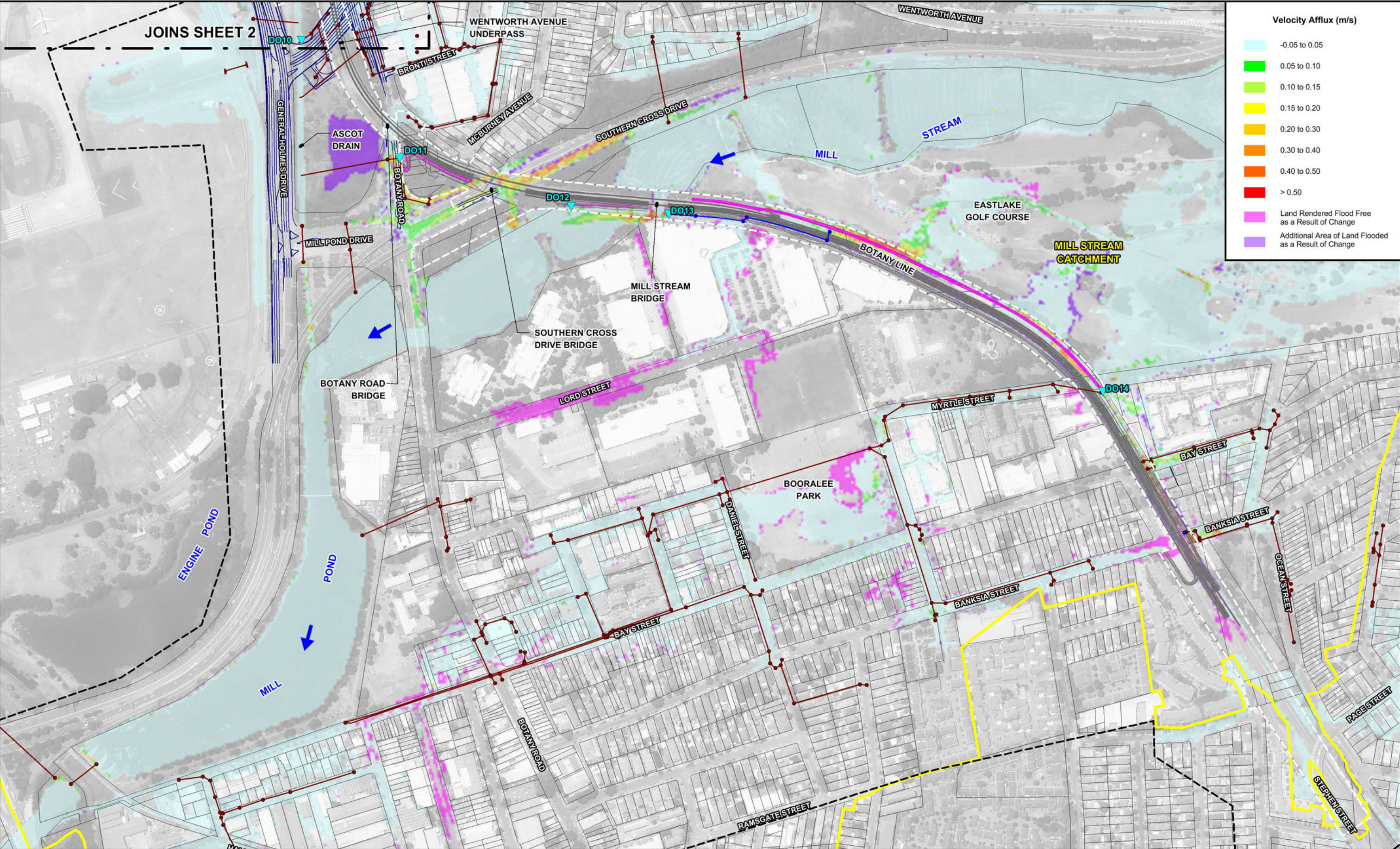


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Note:
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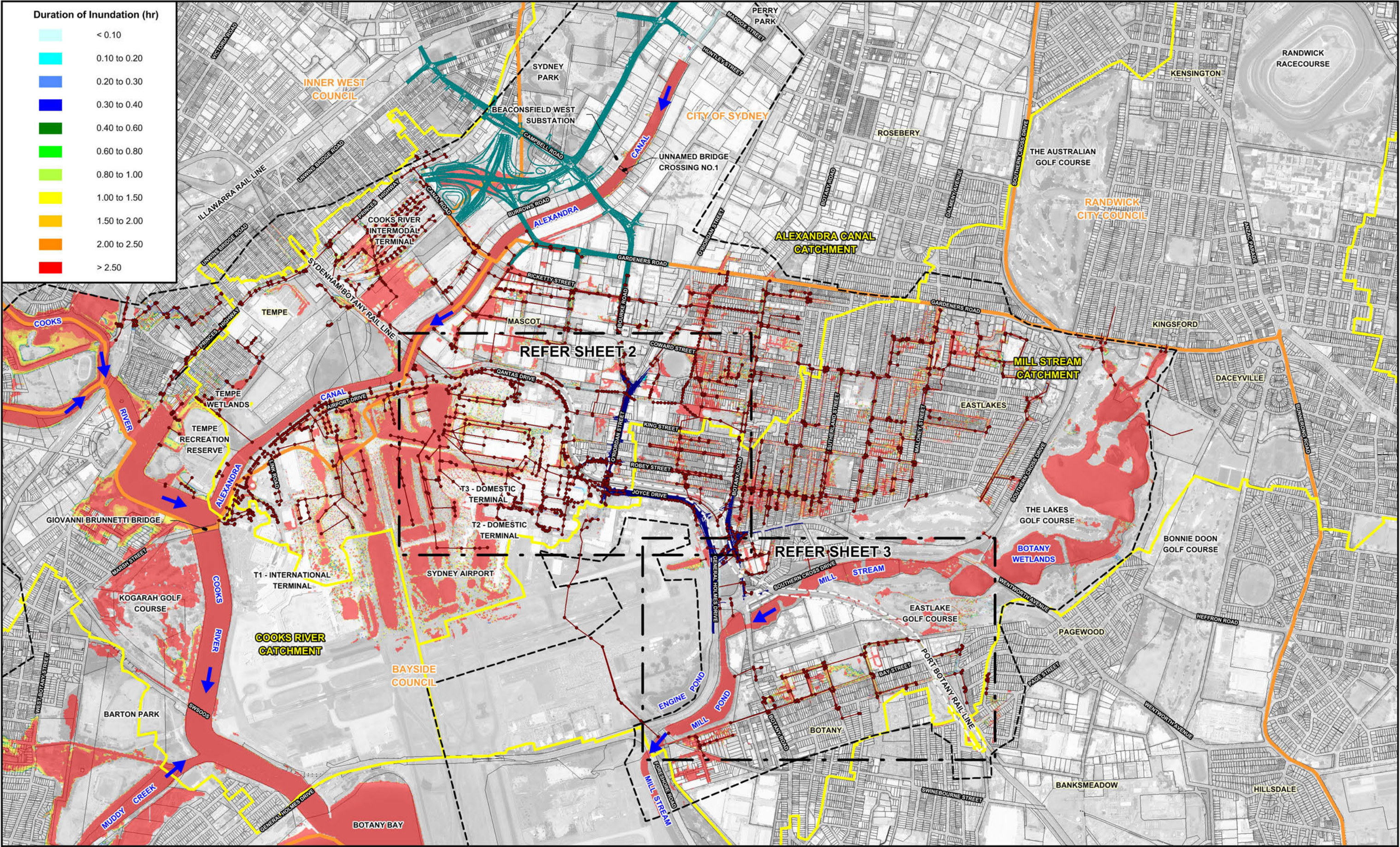
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- LEGEND**
- Two-Dimensional Model Boundary
 - Catchment Boundary
 - Existing Drainage System to Remain
 - Proposed Drainage System

- Proposed Rail Works
- Airport North and Airport East Road Works
- Drainage Outlet Location and Identifier
- Proposed Corridor Access Road
- Project Footprint

**BOTANY RAIL DUPLICATION EIS
TECHNICAL WORKING PAPER: FLOODING**

Figure B.22
(Sheet 3 of 3)
IMPACT OF PROJECT OPERATION ON PEAK FLOW VELOCITIES
1% AEP EVENT



Duration of Inundation (hr)

< 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.50
1.50 to 2.00
2.00 to 2.50
> 2.50

LEGEND

Two-Dimensional Model Boundary	Project Footprint
LGA Boundary	Airport North and Airport East Road Works
Catchment Boundary	New M5 Surface Road Works
Existing Drainage System	

BOTANY RAIL DUPLICATION EIS
TECHNICAL WORKING PAPER: FLOODING

Figure B.23
(Sheet 1 of 3)

DURATION OF INUNDATION
PRE-PROJECT CONDITIONS - 10% AEP EVENT

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Duration of Inundation (hr)

< 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.40
0.40 to 0.60
0.60 to 0.80
0.80 to 1.00
1.00 to 1.50
1.50 to 2.00
2.00 to 2.50
> 2.50

Scale: 1:5,000

50 0 50 100 150 m

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Note:

The ground surface model incorporated in TUFLOW is based on LiDAR survey which has been sampled on a 2m (min.) grid and does not necessarily incorporate localised features which can influence flooding behaviour in individual allotments.

Flood depths are therefore approximate only and require interpretation by a suitably qualified engineer to determine flooding behaviour in individual allotments. Any assessment of flooding in individual allotments may also require a site survey.

LEGEND

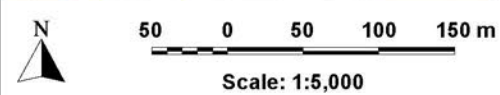
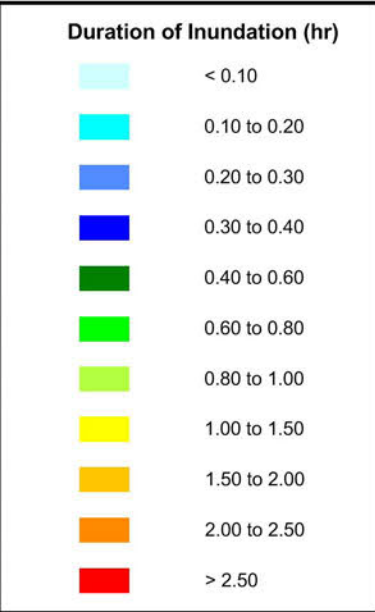
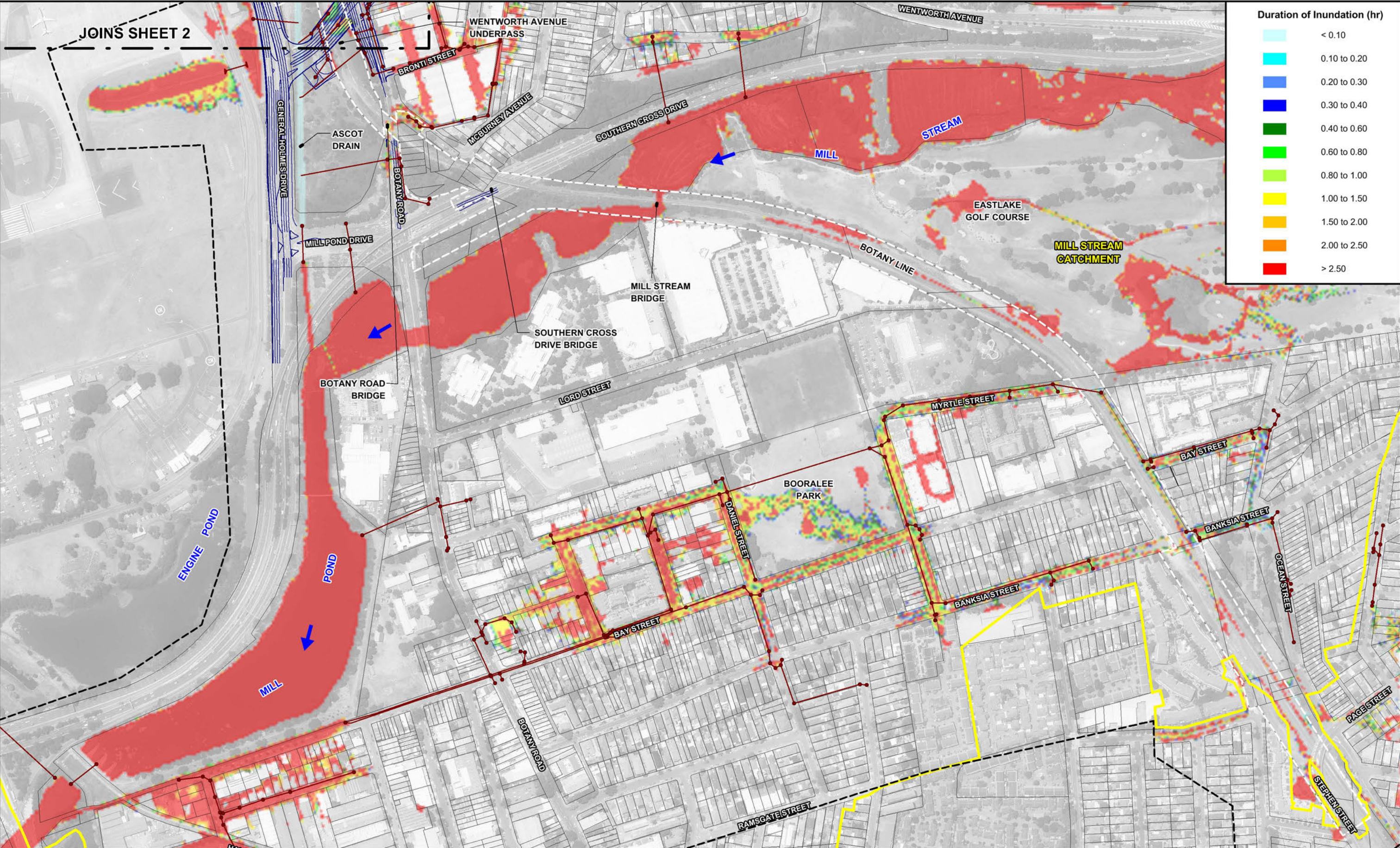
Two-Dimensional Model Boundary	Project Footprint
Catchment Boundary	Airport North and Airport East Road Works
Existing Drainage System	

BOTANY RAIL DUPLICATION EIS

TECHNICAL WORKING PAPER: FLOODING

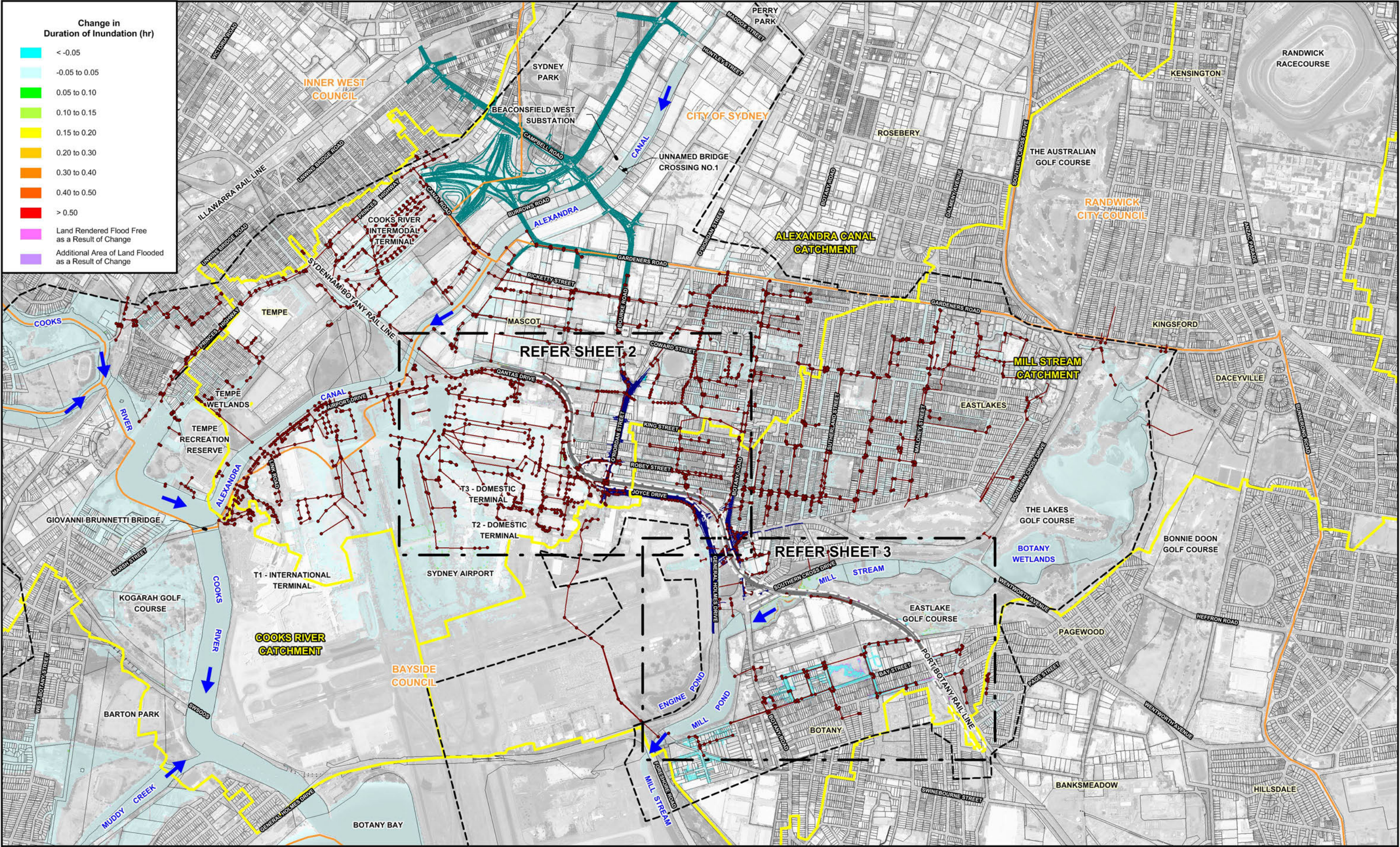
Figure B.23
(Sheet 2 of 3)

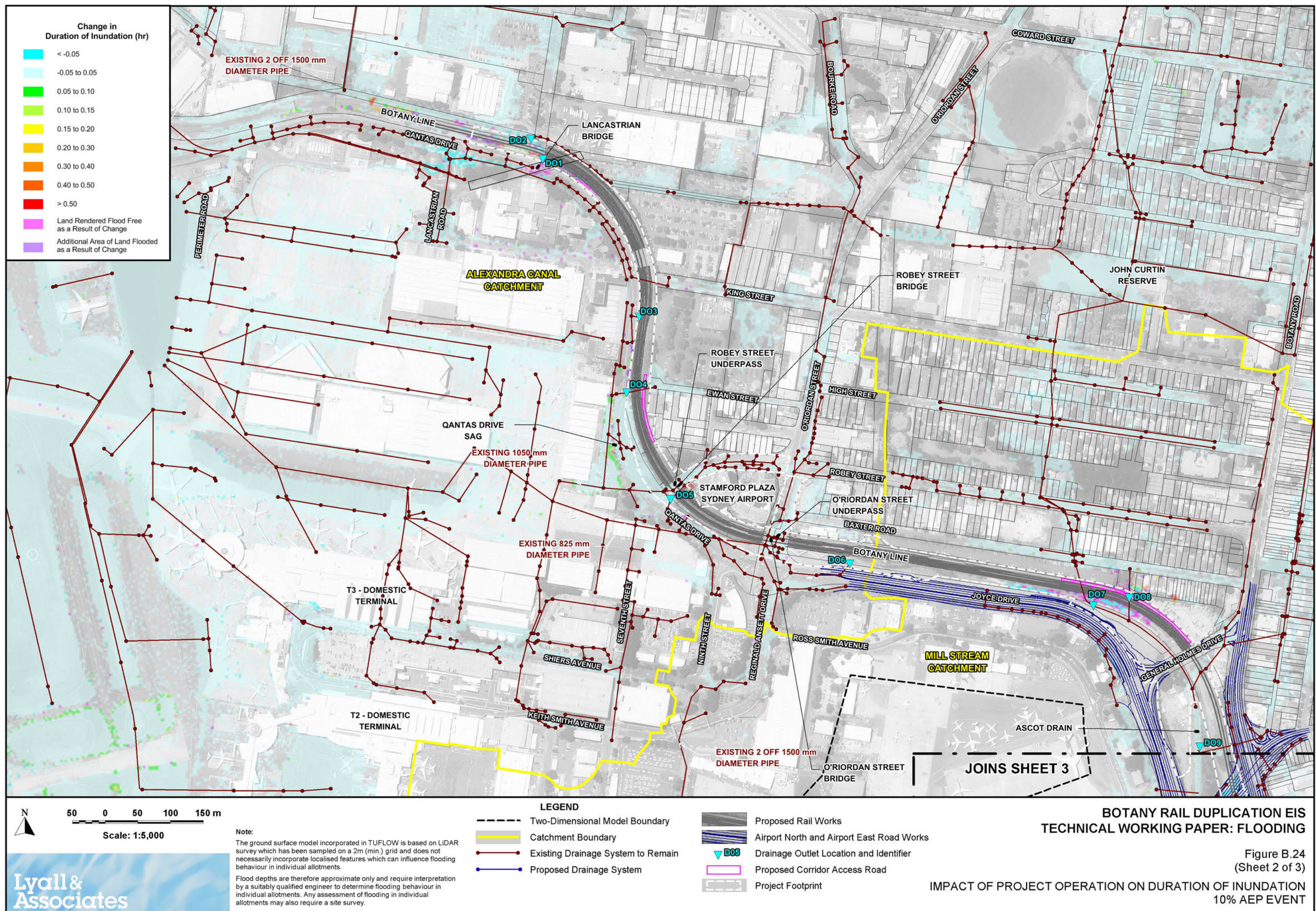
DURATION OF INUNDATION
PRE-PROJECT CONDITIONS - 10% AEP EVENT

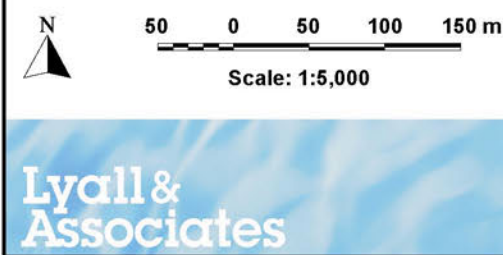
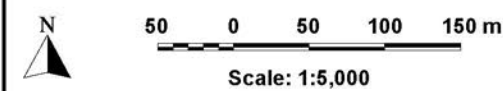
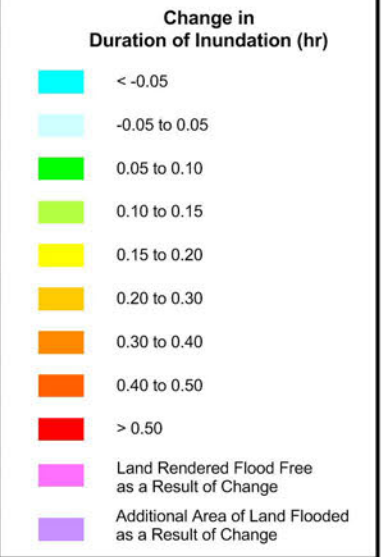
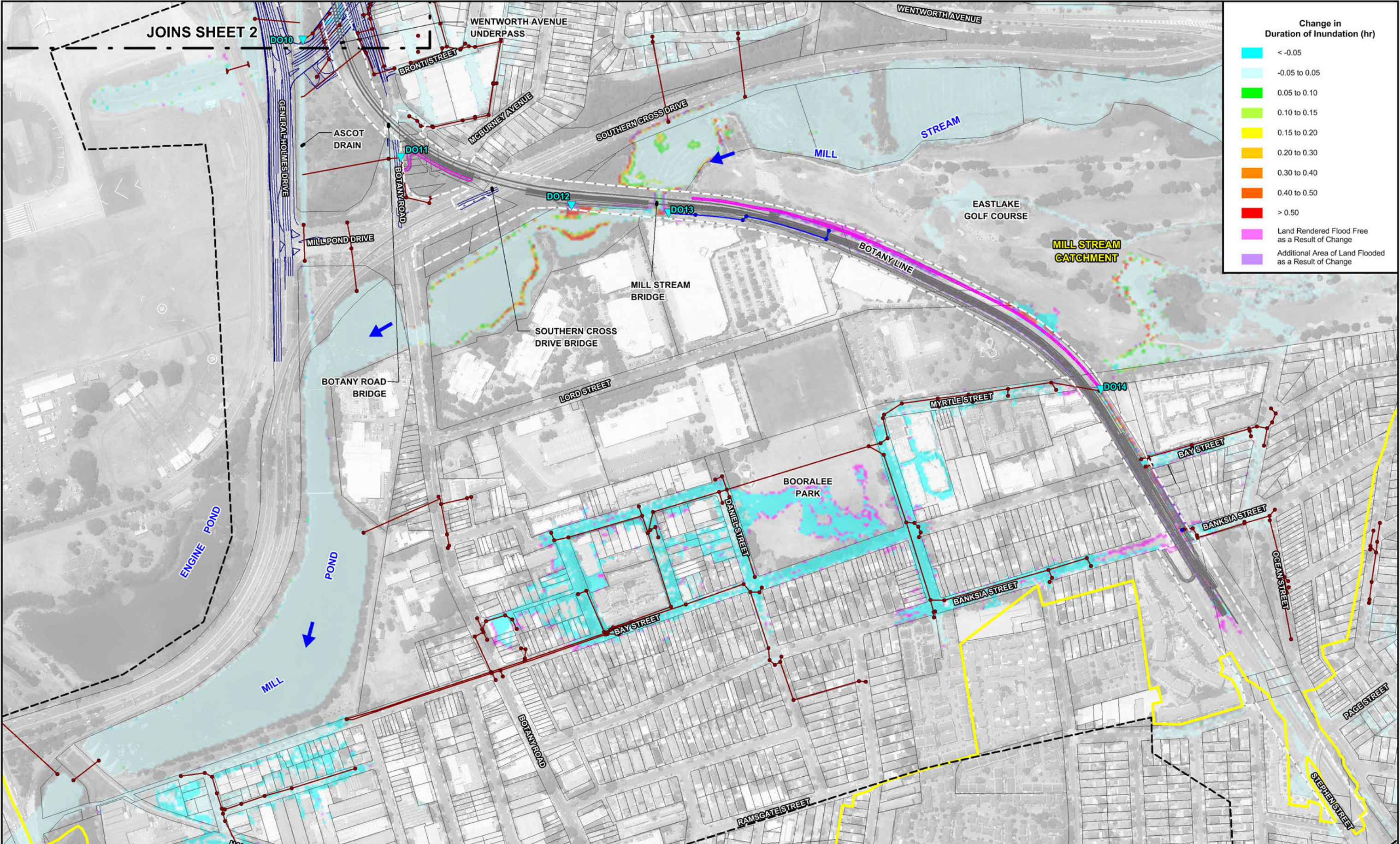


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- LEGEND**
- Two-Dimensional Model Boundary
 - Catchment Boundary
 - Existing Drainage System
 - Project Footprint
 - Airport North and Airport East Road Works



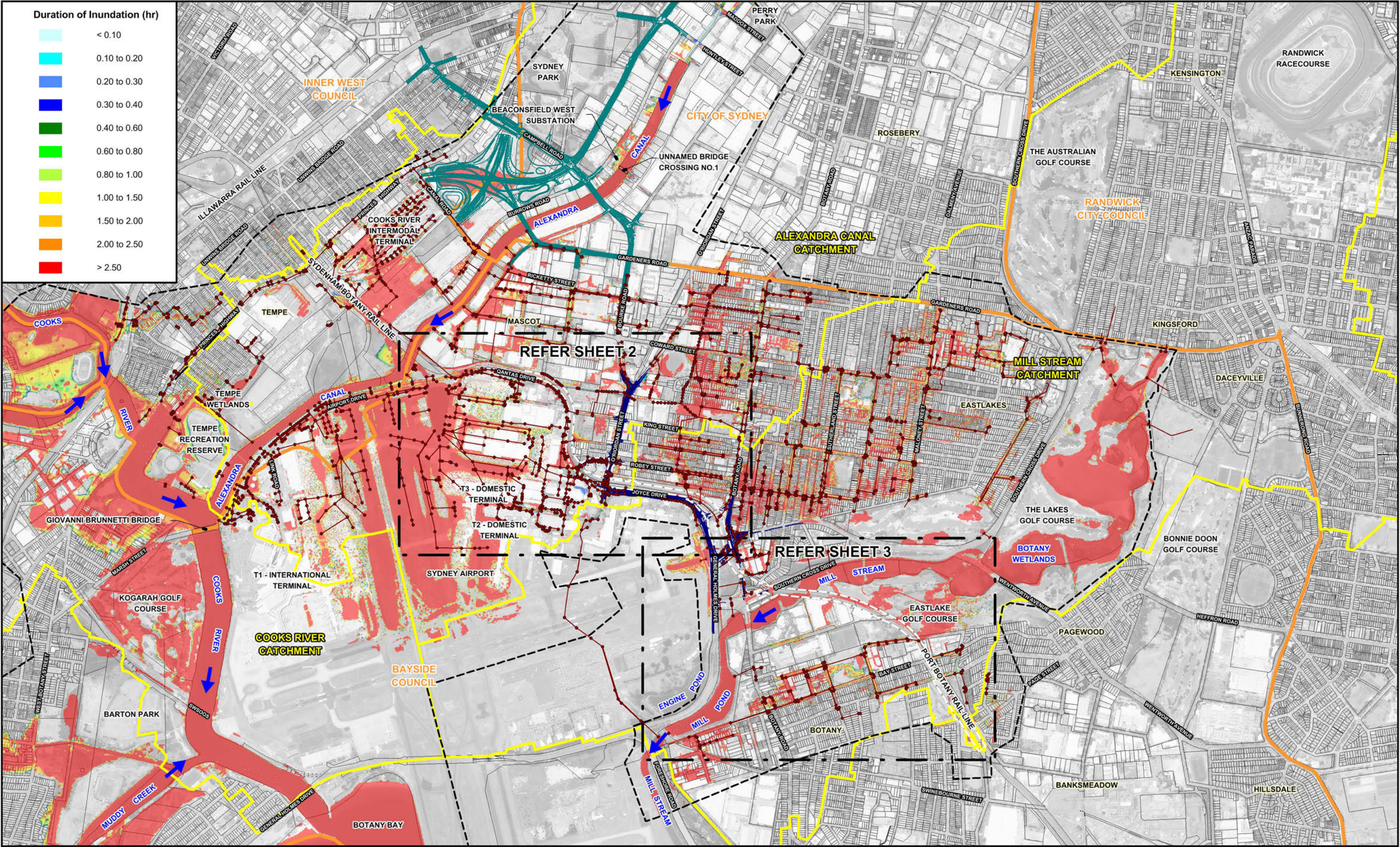


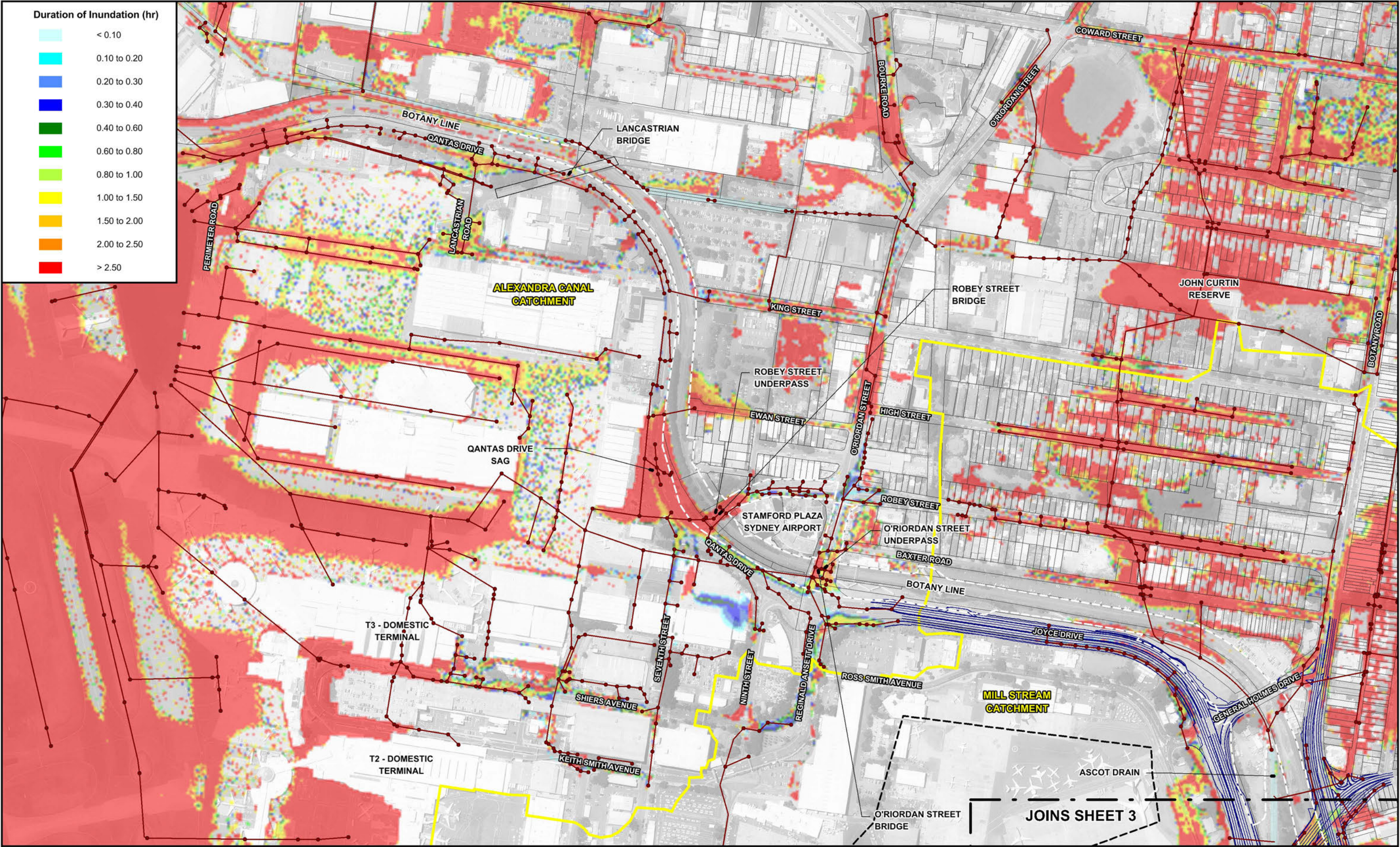


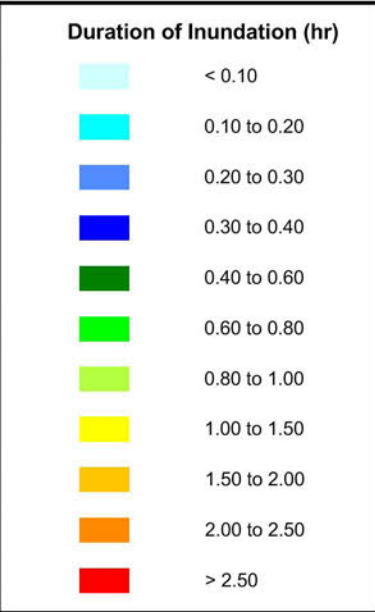
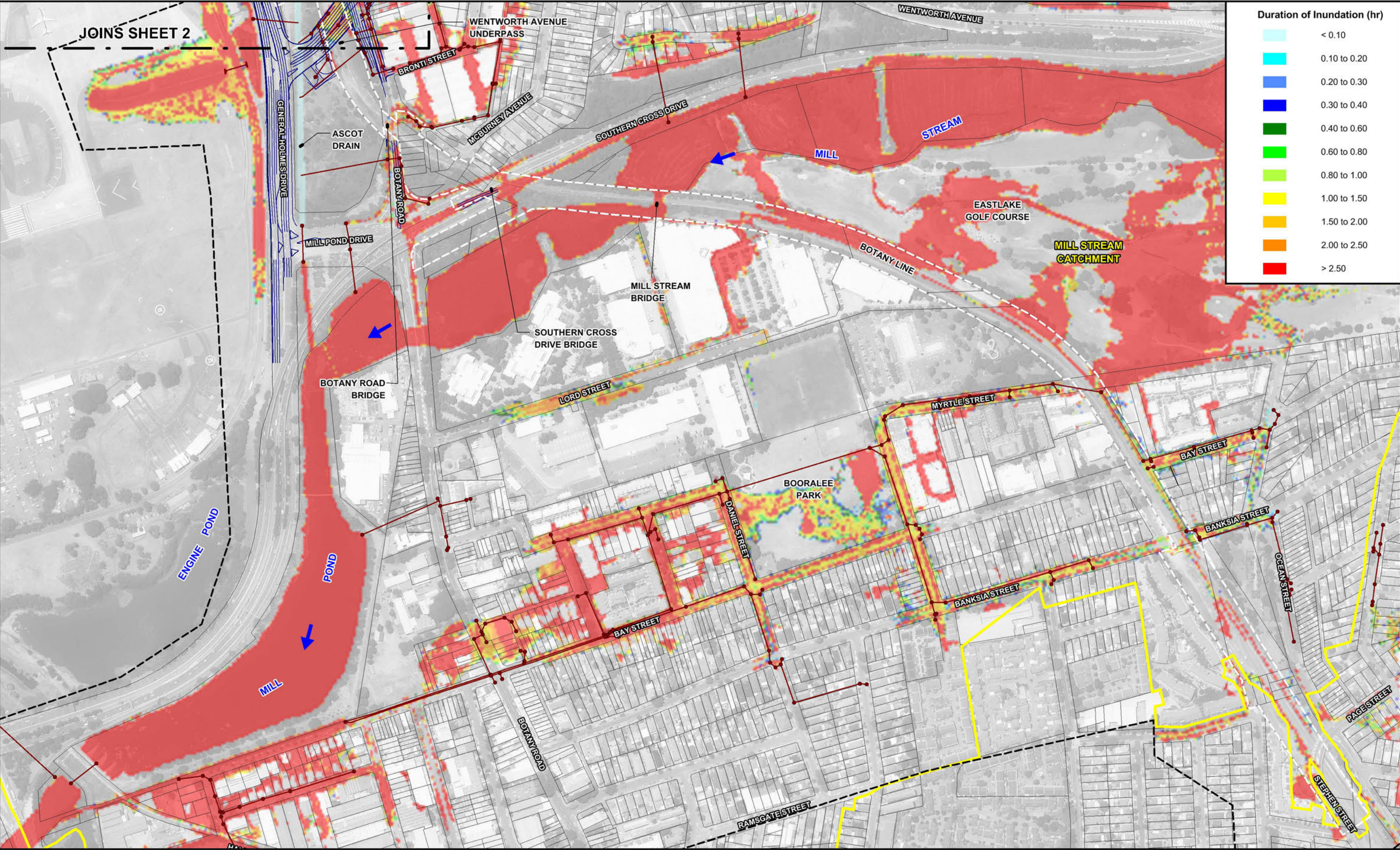
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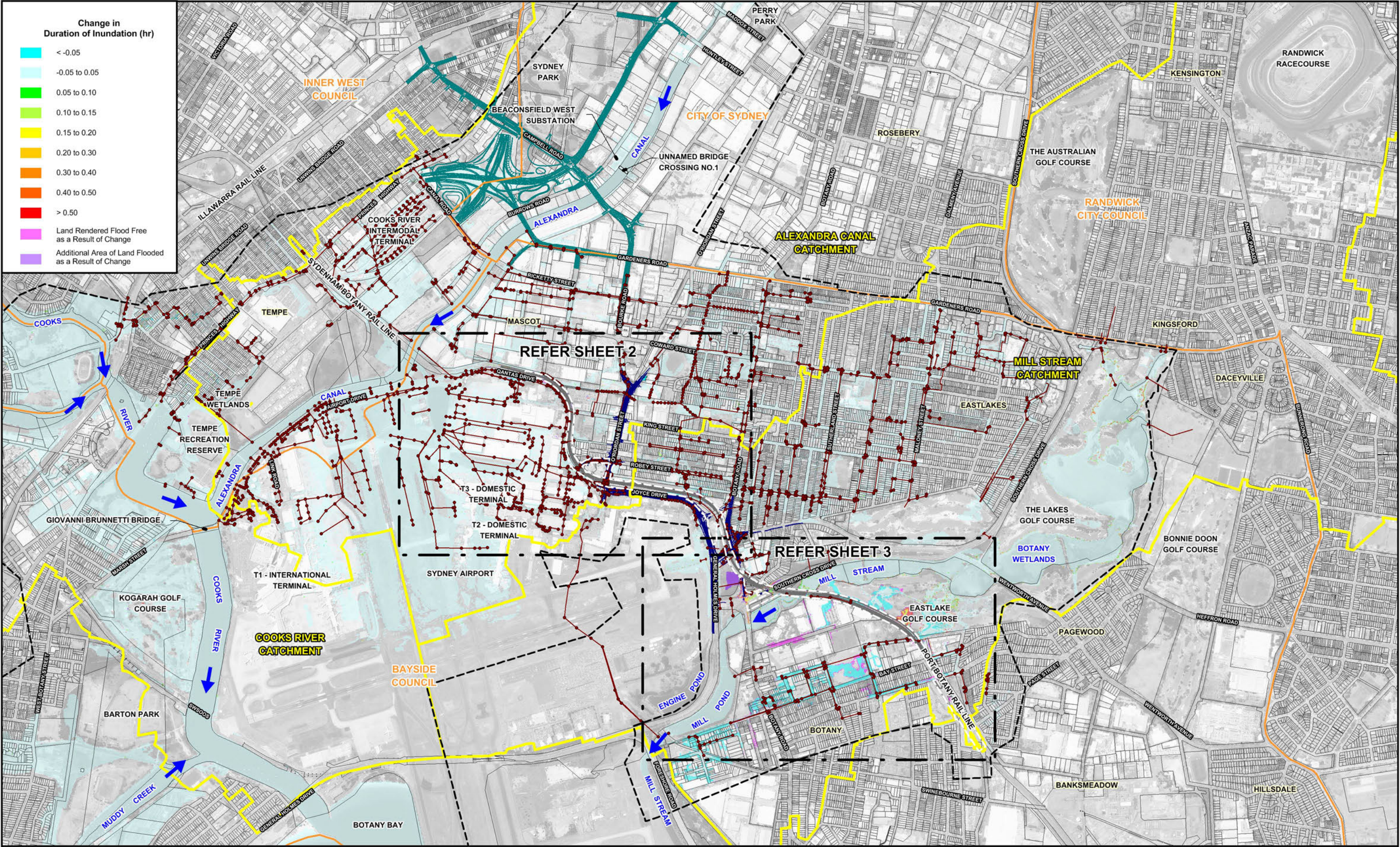
- LEGEND**
- Two-Dimensional Model Boundary
 - Catchment Boundary
 - Existing Drainage System to Remain
 - Proposed Drainage System

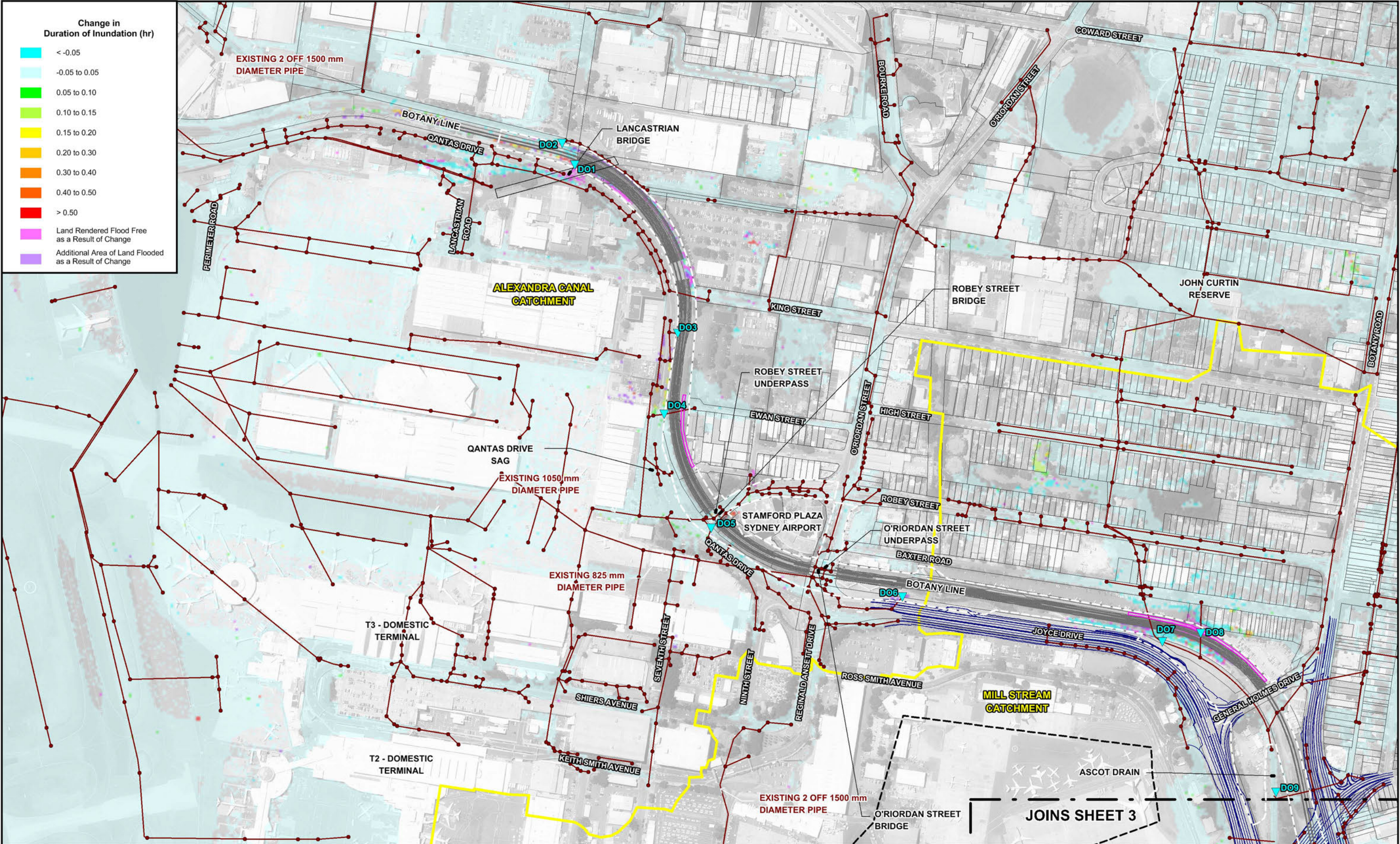
- Proposed Rail Works
- Airport North and Airport East Road Works
- Drainage Outlet Location and Identifier
- Proposed Corridor Access Road
- Project Footprint











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Note:
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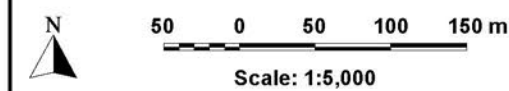
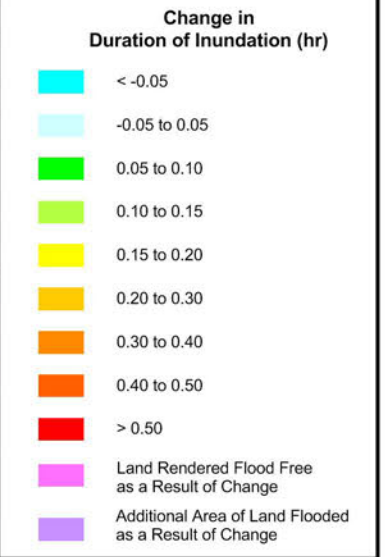
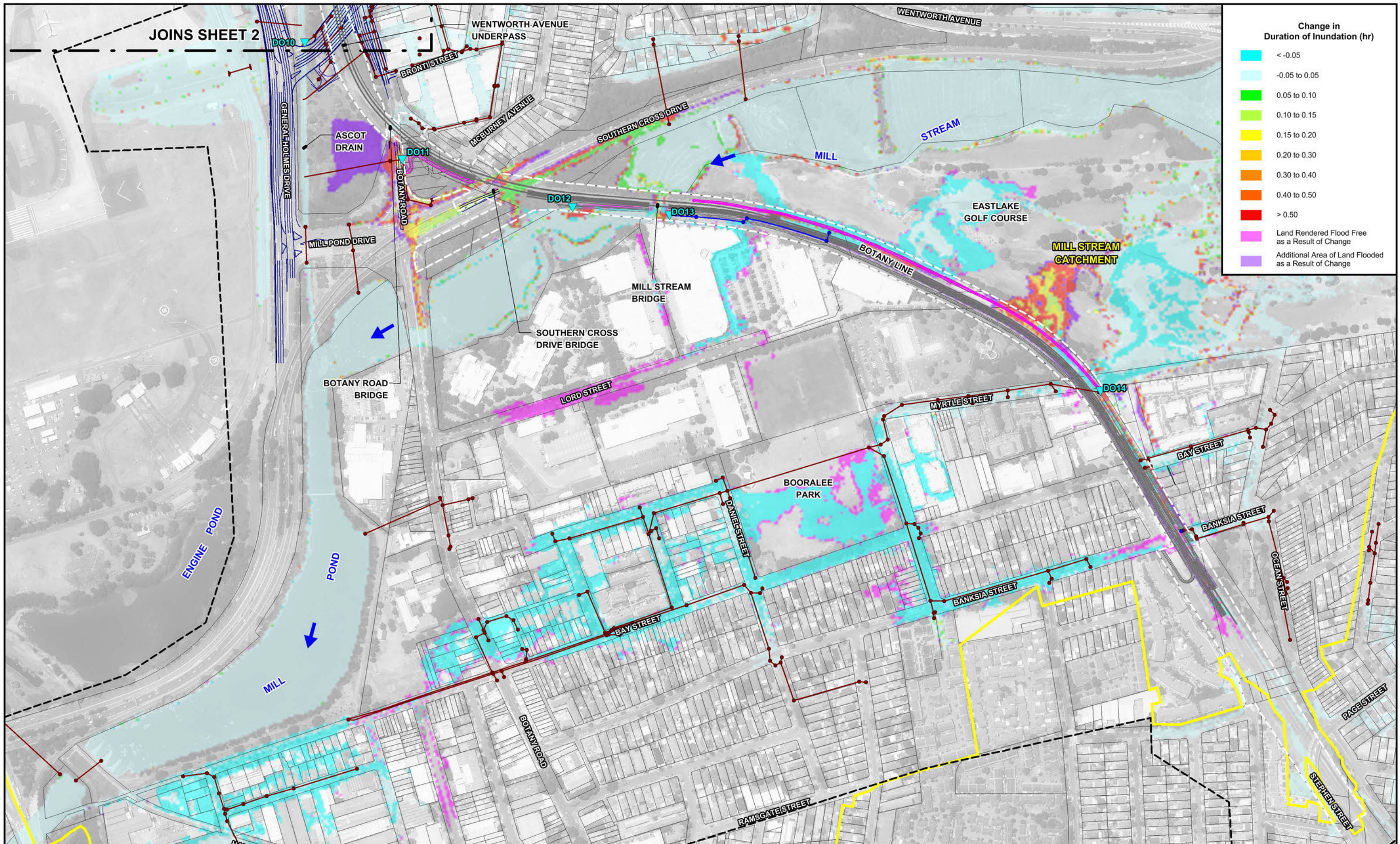
- LEGEND**
- Two-Dimensional Model Boundary
 - Catchment Boundary
 - Existing Drainage System to Remain
 - Proposed Drainage System

- Proposed Rail Works
- Airport North and Airport East Road Works
- Drainage Outlet Location and Identifier
- Proposed Corridor Access Road
- Project Footprint

**BOTANY RAIL DUPLICATION EIS
TECHNICAL WORKING PAPER: FLOODING**

Figure B.26
(Sheet 2 of 3)

IMPACT OF PROJECT OPERATION ON DURATION OF INUNDATION
1% AEP EVENT



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- LEGEND**
- Two-Dimensional Model Boundary
 - Catchment Boundary
 - Existing Drainage System to Remain
 - Proposed Drainage System

- Proposed Rail Works
- Airport North and Airport East Road Works
- Drainage Outlet Location and Identifier
- Proposed Corridor Access Road
- Project Footprint

**BOTANY RAIL DUPLICATION EIS
TECHNICAL WORKING PAPER: FLOODING**

Figure B.26
(Sheet 3 of 3)

**IMPACT OF PROJECT OPERATION ON DURATION OF INUNDATION
1% AEP EVENT**

ANNEXURE C
ANALYSIS OF RECORDED RAINFALL DURING STORMS OF
7 SEPTEMBER 2018 AND 28 NOVEMBER 2018

C1. ANALYSIS OF RECORDED RAINFALL DURING STORM OF SEPTEMBER 2018

C1.1. Overview

A severe thunderstorm hit Sydney on the afternoon of 7 September 2018 that brought heavy rainfall, hail and damaging winds across the city. Flash flooding was reported at a number of locations in Sydney, including the low point in the Robey Street Underpass. **Plate C.1** is a photo that was taken during the storm which indicates that the depth of ponding at the low point could have been in the order of 0.2 to 0.3 metres.

An analysis of the rainfall that was recorded at Sydney Airport during the storm is provided in the following section.



Plate C.1: Photo taken during storm of 7 September 2018 showing flooding to the low point in the Robey Street Underpass. The water level against the fence that is located to the left of the road indicates that the depth of inundation was likely to have been in the order of 0.2 to 0.3 metres. [Source: Sydney Morning Herald website]

C1.2. Analysis of Recorded Rainfall

Rainfall recorded at the Sydney Airport was obtained from the BoM for the storm which occurred in September 2018 to assess the likely depth of rainfall at Robey Street and to compare it against design rainfall depths for a range of durations.

Figure C.1 at the end of this annexure shows the cumulative rainfall depth at Sydney Airport for the period between 21:00 hours on 6 September 2018 and 21:00 hours on 7 September 2018. Steady rain commenced at around 23:30 hours on 6 September 2018 but only lasted for around two hours, resulting in a total rainfall depth of just 3 millimetres. More intense rainfall commenced at around 15:30 hours on 7 September and continued through to around 20:00 hours on the same day. The total depth of rain which fell during this period amounted to 30 millimetres.

Table C.1 provides a summary of maximum recorded rainfall depths during the storm of 7 September 2018 for durations ranging between 30 minutes and 6 hours, together with the corresponding AEP of the storm based on a comparison with design rainfall depths that were derived using procedures set out in both ARR 1987 and ARR 2019. **Figure C.2** at the end of this annexure shows the same information plotted on a log normal graph along with curves showing the design rainfall depths for a 1 EY storm together with a range of storms with AEP's between 50 and 1 per cent.

The analysis shows that for durations of between 30 minutes and six hours the storm was equivalent to less than a 1 EY event.

TABLE C.1
SUMMARY OF MAXIMUM RECORDED RAINFALL INTENSITIES DURING
7 SEPTEMBER 2018 STORM

Duration	Rainfall Intensity (mm/hour)	Equivalent Probability (ARR 1987)	Equivalent Probability (ARR 2016)
30 minutes	28.0	< 1 EY	< 1 EY
1 hour	18.8	< 1 EY	< 1 EY
1.5 hours	13.3	< 1 EY	< 1 EY
2 hours	10.9	< 1 EY	< 1 EY
3 hours	9.1	< 1 EY	< 1 EY
4.5 hours	6.7	< 1 EY	< 1 EY
6 hours	5.0	< 1 EY	< 1 EY

- (1) The calculated probability is based on a comparison of recorded rainfall depths with design rainfall depths obtained from the Bureau of Meteorology website based on *Australian Rainfall and Runoff, 1987*.
- (2) The calculated probability is based on a comparison of recorded rainfall depths with design rainfall depths obtained from the Bureau of Meteorology website based on *Australian Rainfall and Runoff, 2016*.

C2. ANALYSIS OF RECORDED RAINFALL DURING STORM OF NOVEMBER 2018

C2.1. Overview

A severe thunderstorm hit Sydney on the morning of 28 September 2018 that brought heavy rainfall across the city. Flash flooding was reported at a number of locations in Sydney, including the low point in the O’Riordan Street Underpass. A video taken of the flooding to the underpass indicates that the depth of ponding at the low point could have been in the order of 0.5 metres.

An analysis of the rainfall that was recorded at Sydney Airport during the storm is provided in the following section.

C2.2. Analysis of Recorded Rainfall

Rainfall recorded at the Sydney Airport was obtained from the Bureau of Meteorology (**BoM**) for the storm which occurred in November 2018 to assess the likely depth of rainfall at O’Riordan Street and to compare it against design rainfall depths for a range of durations.

Figure C.1 at the end of this annexure shows the cumulative rainfall depth at Sydney Airport for the period between 02:00 hours on 28 November 2018 and 02:00 hours on 29 November 2018. Rainfall commenced just after 05:00 hours on 28 November 2018 and the most intense period of rainfall occurred between 06:00 hours and 07:30 hours on 28 November 2018. The total depth of rain which fell during this period amounted to 30 millimetres.

Table C.2 over the page provides a summary of maximum recorded rainfall depths during the storm of 28 November 2018 for durations ranging between 30 minutes and six hours, together with the corresponding AEP of the storm based on a comparison with design rainfall depths that were derived using procedures set out in both ARR 1987 and ARR 2019. **Figure C.2** at the end of this annexure shows the same information plotted on a log normal graph along with curves showing the design rainfall depths for a 1 EY storm together with a range of storms with AEP’s between 50 and 1 per cent.

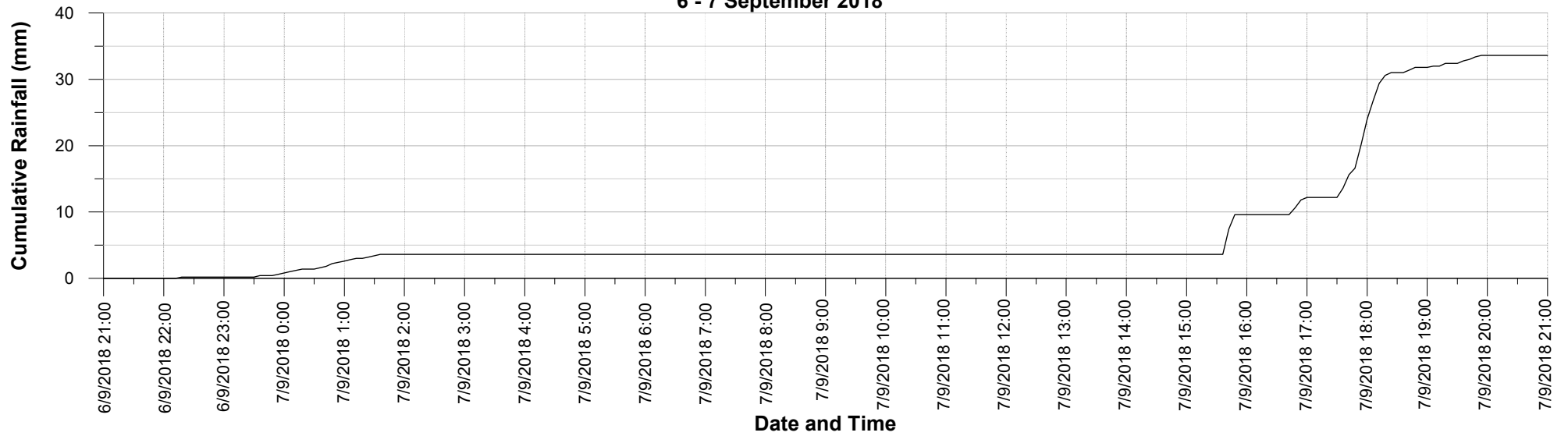
The analysis shows that for durations of between 30 minutes and six hours the storm was equivalent to less than a 1 EY event.

TABLE C.2
SUMMARY OF MAXIMUM RECORDED RAINFALL INTENSITIES DURING
28 NOVEMBER 2018 STORM

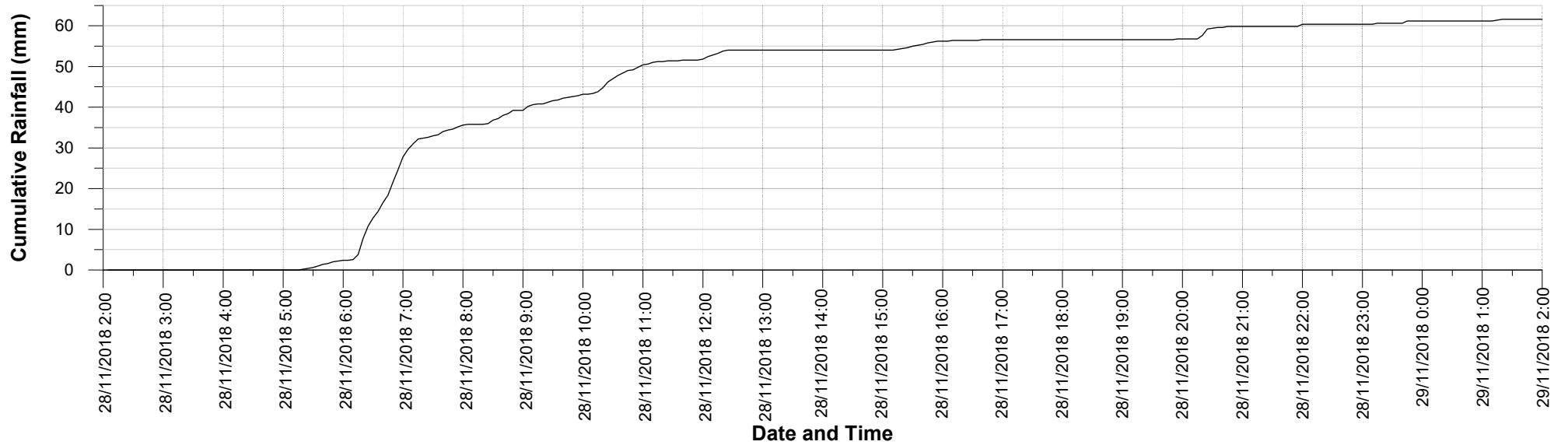
Duration	Rainfall Intensity (mm/hour)	Equivalent Probability (ARR 1987)	Equivalent Probability (ARR 2016)
30 minutes	30.4	< 1 EY	< 1 EY
1 hour	28.4	< 1 EY	< 1 EY
1.5 hours	20.9	< 1 EY	< 1 EY
2 hours	16.7	< 1 EY	< 1 EY
3 hours	12.7	< 1 EY	< 1 EY
4.5 hours	10.2	< 1 EY	< 1 EY
6 hours	8.5	< 1 EY	< 1 EY

- (1) The calculated probability is based on a comparison of recorded rainfall depths with design rainfall depths obtained from the Bureau of Meteorology website based on *Australian Rainfall and Runoff, 1987*.
- (2) The calculated probability is based on a comparison of recorded rainfall depths with design rainfall depths obtained from the Bureau of Meteorology website based on *Australian Rainfall and Runoff, 2016*.

**Sydney Airport - [066037]
6 - 7 September 2018**



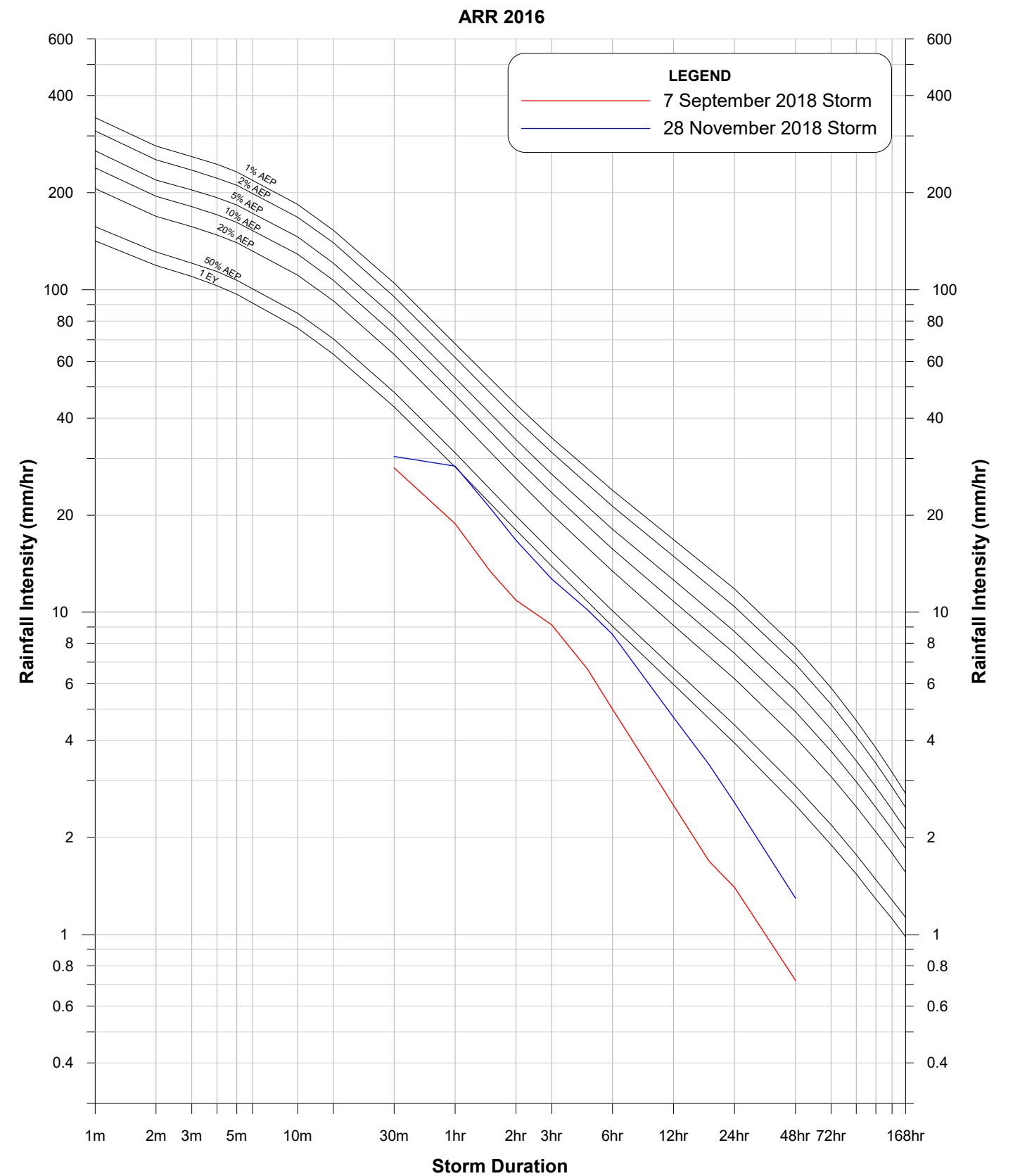
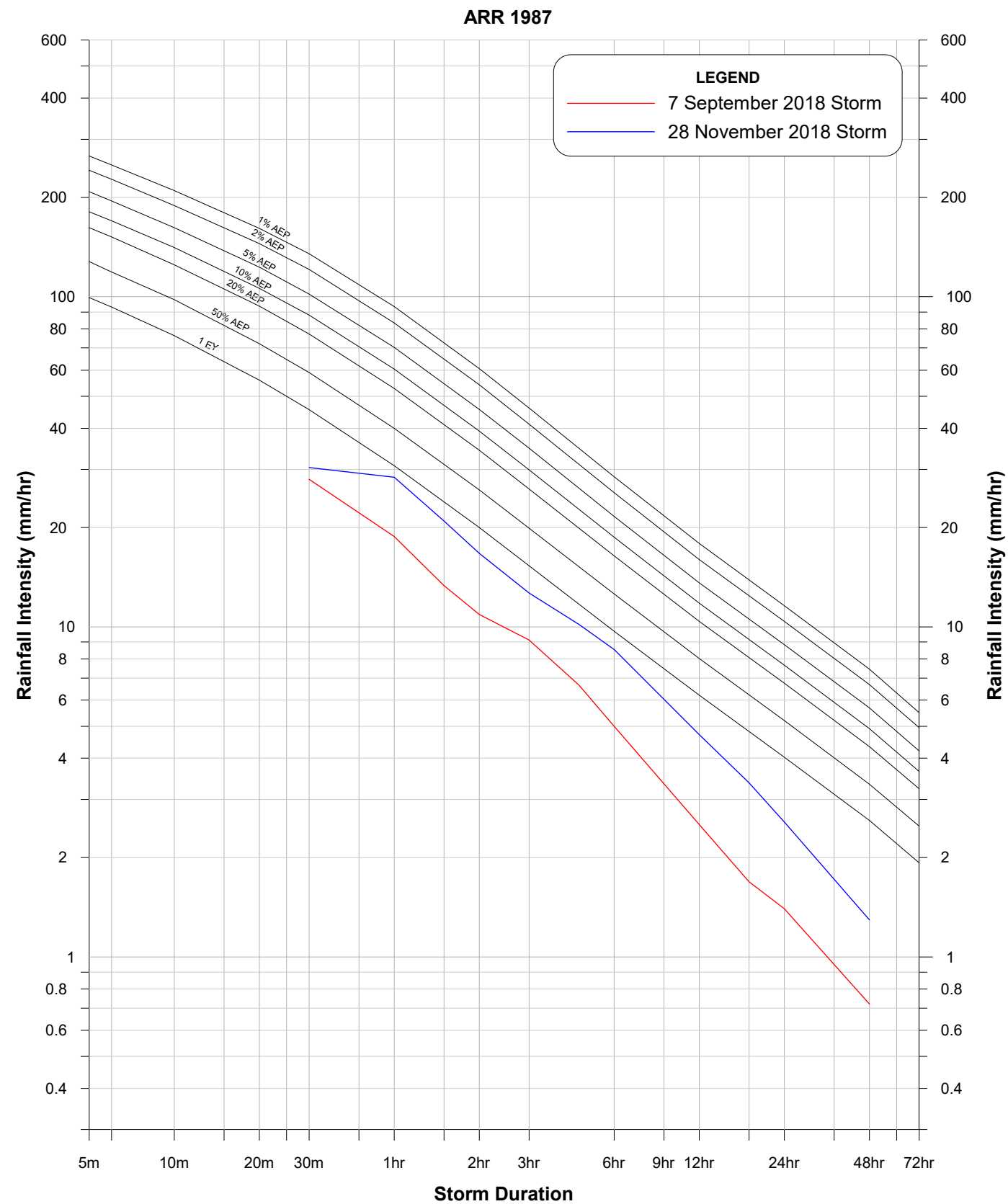
**Sydney Airport - [066037]
28 - 29 November 2018**



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Figure C.1

CUMULATIVE RAINFALL
HISTORIC STORM EVENTS



**BOTANY RAIL DUPLICATION EIS
TECHNICAL WORKING PAPER: FLOODING**

Figure C.2

INTENSITY-FREQUENCY-DURATION CURVES
AND HISTORIC RAINFALL