Kennedy Creek – Flooding Investigation

May 2015

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PROJECT DETAILS

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GLOSSARY OF TERMS

Annual Exceedance Probability (AEP)	Refers to the probability or risk of a rainfall event of a given magnitude (intensity and duration) occurring or being exceeded in any given year. A 90% AEP event has a high probability of occurring or being exceeded; it would occur quite often and would be a relatively minor rainfall event. A 1% AEP event has a low probability of occurrence or being exceeded; it would be rare but it would be likely to cause extensive damage.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level. Introduced in 1971 to eventually supersede all earlier datums.
Average Recurrence Interval (ARI)	Refers to the average time interval between a given flood magnitude occurring or being exceeded. A 10 year ARI flood is expected to be exceeded on average once every 10 years. A 100 year ARI flood is expected to be exceeded on average once every 100 years. The AEP is the ARI expressed as a percentage.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. Generally relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design standards. A design flood will generally have a nominated AEP or ARI (see above).
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from elevated sea levels and/or waves overtopping coastline defences.
Flood damage	The tangible and intangible costs of flooding.
Flood hazard	Potential risk to life and limb caused by flooding. Flood hazard combines the flood depth and velocity.
Flood mitigation	A series of works to prevent or reduce the impact of flooding. This includes structural options such as levees and non-structural options such as planning schemes and flood warning systems.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Flood storages	Those parts of the floodplain that are important for the temporary storage, of floodwaters during the passage of a flood.
Freeboard	A factor of safety above design flood levels typically used in relation to the setting of floor levels or crest heights of flood levees. It is usually expressed as a height above the level of the design flood event.
Geographical information systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.

Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Intensity frequency duration (IFD) analysis	Statistical analysis of rainfall, describing the rainfall intensity (mm/hr), frequency (probability measured by the AEP), duration (hrs). This analysis is used to generate design rainfall estimates.
TUFLOW	A hydraulic modelling tool used in this study to simulate the flow of flood water through the floodplain. The model uses numerical equations to describe the water movement.
Ortho-photography	Aerial photography which has been adjusted to account for topography. Distance measures on the ortho-photography are true distances on the ground.
Peak flow	The maximum discharge occurring during a flood event.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Average Recurrence Interval.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequence and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
RORB	A hydrological modelling tool used in this study to calculate the runoff generated for design rainfall events.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
Topography	A surface which defines the ground level of a chosen area.

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1. INTRODUCTION

In late 2013 Benalla Rural City Council (BRCC) commissioned several investigations into drainage related matters in Benalla. Water Technology undertook an investigation into capacity constraints in the Eastern Main Drain and available mitigation options. A spin off from this original work was a high level investigation into flooding in the Kennedy Creek catchment. Drivers for the this study were existing flooding problems (Sydney Road) and the requirement for flooding in the land the north east of the town currently zoned industrial to be better understood.

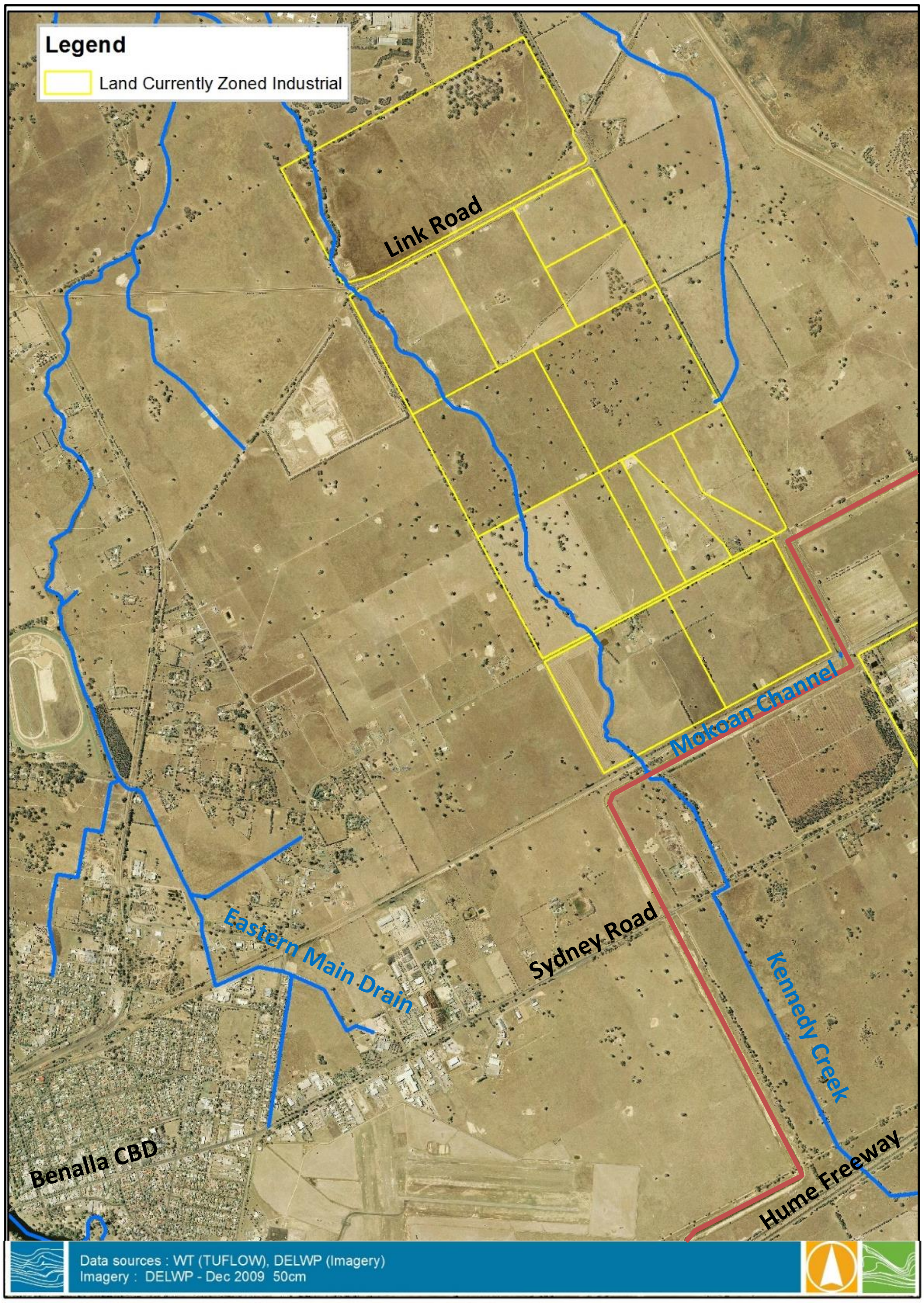

Figure 1-1 Key features inside the Kennedy creek study area

2. SCOPE OF WORKS

To achieve the project objectives the following key tasks were undertaken:

- Gather and review available data;
- Scope survey to fill data gaps;
- Construct hydrological (RORB) model of the Kennedy Creek catchment and produce results from the 5 and 100 year Annual Recurrence Interval (ARI) flood events for peak durations;
- Construct a TUFLOW hydraulic model of the subject site;
- Run the TUFLOW model for the 5 and 100 year ARI events;
- Assess results and provide maps showing the peak flood extents across the 5 and 100 year ARI events. Provide maps showing peak depths, velocities and flood hazard for the 100 year ARI event.
- Provide clear and concise reporting of the methodology and results;
- Provide recommendations on potential mitigation options and meet with Council to discuss; and,
- Test mitigation options (max 2) in the hydraulic model and provide flood depth and difference plots.

3. AVAILABLE INFORMATION REVIEW

3.1 Data Collation

Several different datasets were made available for review at the beginning of the project. A preliminary review of this data was used to identify data gaps and scope initial survey requirements. Key data collated included:

Industry Standards:

- Infrastructure Design Manual (IDM) V4.2 (IDM Board 2013);
- Urban Stormwater Best Practice Environmental Management Guidelines (CSIRO 2006);
- Best Practice Principles for Floodplain Management in Australia (CSIRO 2000);
- Melbourne Water Corporation Flood Mapping Projects Guidelines and Technical Specifications (Nov, 2012);
- 2D Modelling Guidelines for Melbourne Water – Version 1 (Mar 2011); and,
- Australian Standard AS3500.3 Stormwater Drainage.

Spatial data:

- Light Detection and Ranging (LiDAR) topographic data (DEPI);
- Satellite derived digital elevation data (10 m & 20 m resolution) (DEPI);
- Aerial imagery 2009 (DEPI);
- Cadastral and Planning layers (VicMap data) (DEPI); and,
- Council GIS data including drainage focused data such as pit and pipe information.

Historic Flood information:

- Flood imagery from 1993 (GBCMA);
- Estimated flood levels 1993 (GBCMA); and,
- Broken River Catchment Floods – October 1993 (Volume 4) - Dept. of Conservation & Natural Resources (report by Hydrotechnology)

3.1.1 Historic Flooding Information

To our knowledge no specific study into flooding in the Kennedy Creek catchment has ever been undertaken. As part of the desktop review, Water Technology reviewed a report into the 1993 flood event. Again no specific commentary about flooding in Kennedy Creek was noted. The image shown in Figure 3-1 is extracted from this report. It covers a small portion of the study area. Flooding in 1993 has been estimated to be a 1 in 100 year ARI.

Six 1993 flood levels inside the study area were found in the Victorian Flood Database. Their locations and levels are shown in Figure 3-2.

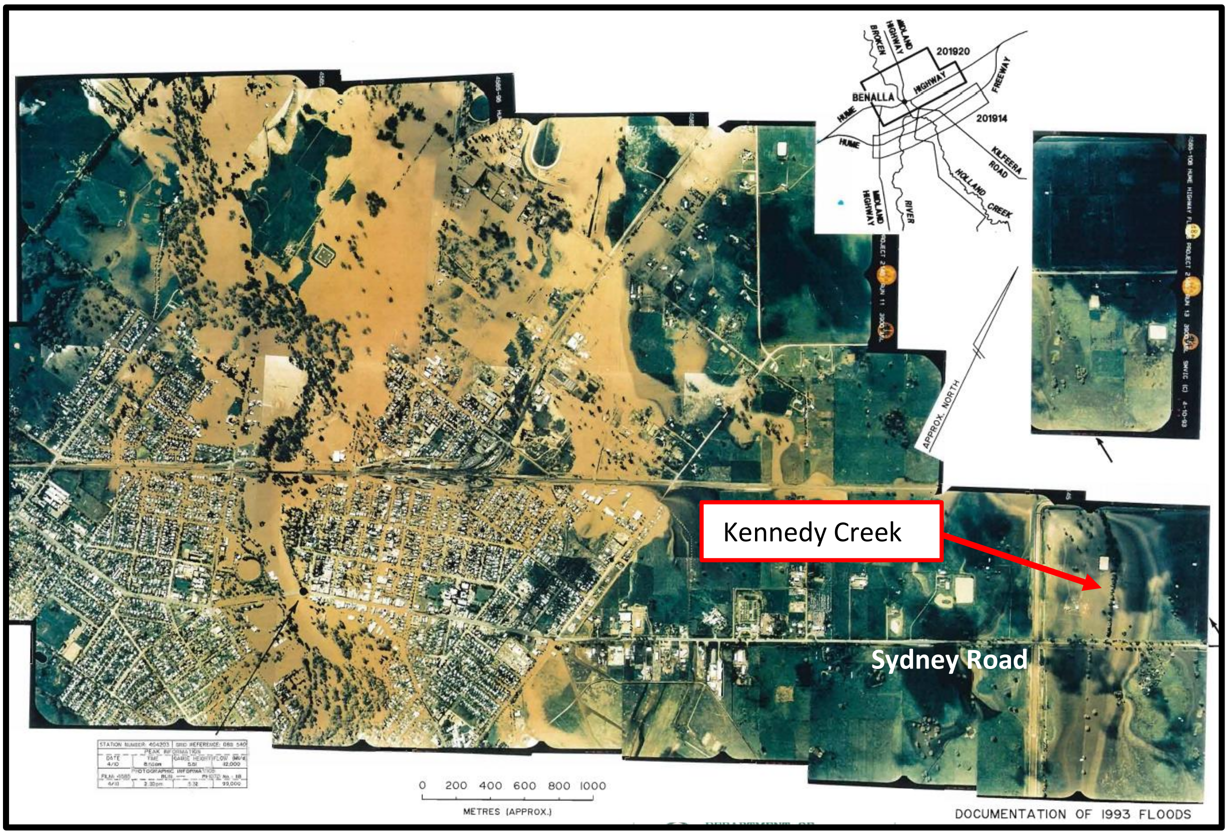

Figure 3-1 1993 Flood mosaic image (Dept. of Conservation & Natural Resources 1993)

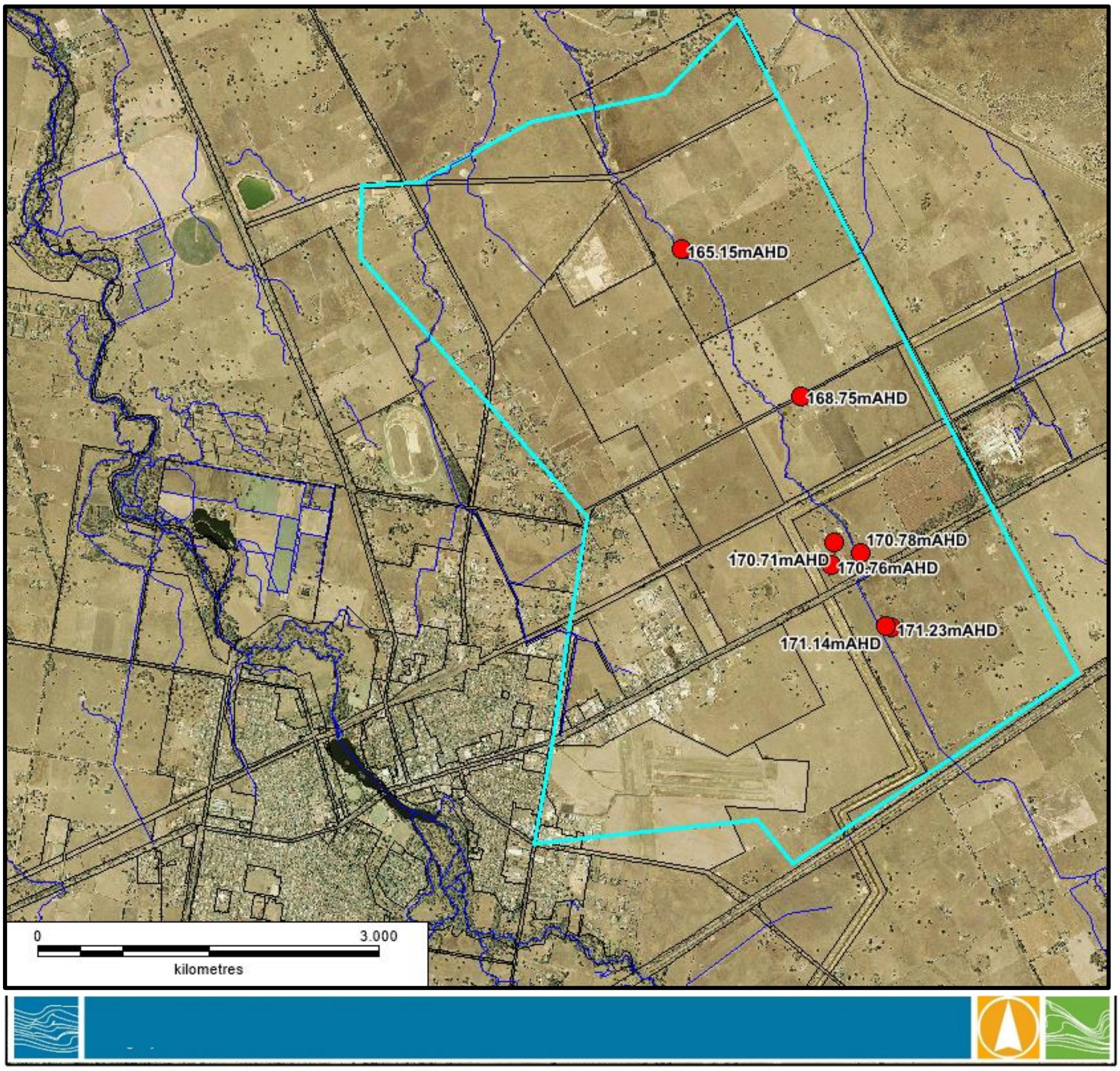

Figure 3-2 1993 Flood Levels (Victorian Flood Database)

3.1.2 Data Gaps

The main data gaps identified were survey related. Water Technology worked closely with EDM group and BRCC to collect the most economical and accurate survey to close the data gaps.

Features / crossings

10 crossing features were surveyed by EDM group. A section of these are depicted in Figure 3-3. Each of these crossings where included as 1D elements in the hydraulic model. Crossing geometry and elevation data was included in the hydraulic model to ensure hydraulic capacities could be resolved in the TUFLOW model.

Figure 3-3 Examples of feature Survey by EDM group

Topography

The most significant data gap in this study was the lack of accurate topographical data within about 50% of the study area. Initially this data gap was attempted to be resolved with land based feature survey, but it quickly become evident that it could not be collected at sufficient resolution to accurately flood model the Kennedy Creek floodplain.

A sub-consultant was engaged to collect Unmanned Aerial Vehicle (UAV) topographic and photographic data. Australian UAV undertook several days of data collection flights in January 2015 to infill the region inside the study area with no high resolution topography. Interesting during this period a pipe laying contractor was laying the new gas main through the Kennedy Creek floodplain. This anomaly had to be later edited out of the topographic data.

The UAV topography was integrated with the available LiDAR topography to create a seamless topographic dataset across the study area. Some discontinuities were noted at the dataset boundaries. These were resolved by interpolating the two datasets at the boundaries to ensure water moved freely on the floodplain.

4. HYDROLOGICAL MODELLING

4.1 Overview

A RORB hydrological model was created to determine the 5 and 100 year ARI flow hydrographs affecting the study area. Catchment delineation of the upstream catchment was undertaken utilising the ArcHydro software package. The ArcHydro program employed the VicMap 10m DEM to determine watersheds throughout the catchment, from which the RORB model reach and sub-area data was derived. The RORB model layout is shown in

Figure 4-1.

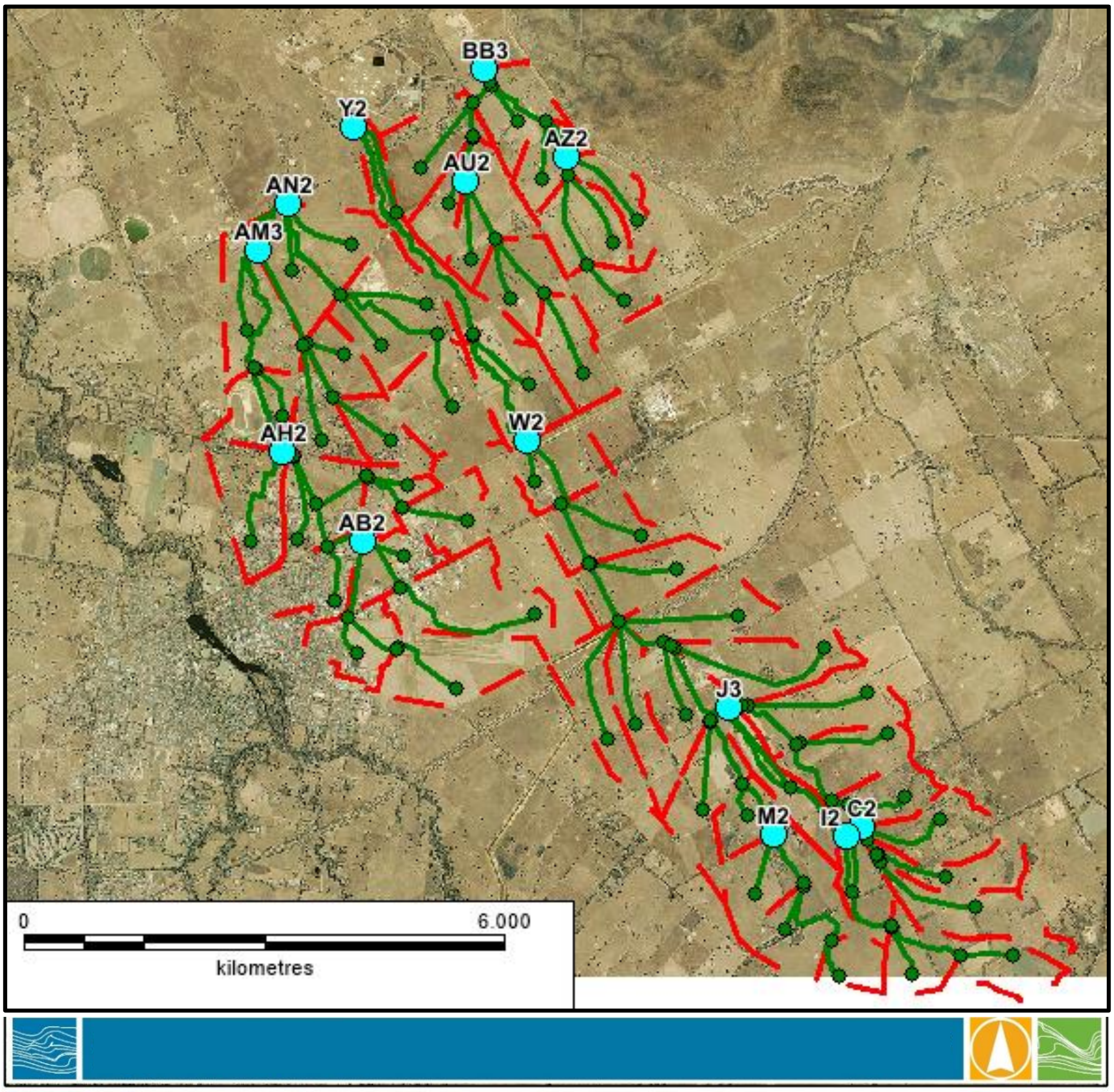

Figure 4-1 RORB model layout

Fraction imperviousness values for the RORB model sub-areas were assigned in accordance with the current planning scheme zoning layers, with each zoning layer allocated a fraction imperviousness value in accordance with Melbourne Water's current MUSIC Guidelines (MWC,2010). The fraction impervious values were then reviewed and adjusted if necessary following a general review of aerial photography and on site observations from a site visit conducted in December 2013.

Thirteen reconciliation points were identified in the setup of the hydrological model. The location of these inflow points is shown in Figure 4-3. The RORB model was reconciled against Rational Method estimates at these locations. Assumptions made in the Rational Method estimate included the following:

– Where possible assumptions and findings from the Enterprise Park assessment were adopted in this study. This included the IFD parameters applied;
– The weighted average fraction imperviousness (FI) values were determine using consistent values from the RORB model;

The resultant 100 year ARI Rational Method calculations for each inflow points is shown in Table 4-1.

Table 4-1 100 Year Rational Method Calculations

Sub-Catchment Name	Area (Km^2)	Weighted Average FI	Q100yr (m^3/s) Rational Method
C2	2.833	0.05	9.88
M2	2.563	0.05	9.19
I2	2.131	0.05	8.04
J3	13.000	0.05	29.64
W2	21.583	0.061	44.11
Y2*	23.787	0.060	47.14
AB2	4.511	0.266	23.42
AH2	8.912	0.252	37.23
AM3	12.917	0.233	46.8
AN2*	17.518	0.05	59.86
AU2	2.638	0.05	9.39
AZ2	2.224	0.058	8.5
BB3*	8.139	0.056	21.59

* Drainage line outlet

4.1.1 RORB Parameters

The RORB model was run with AR&R 1987 method with an aerial reduction factor area of 0.0 km^2. The Initial Loss applied was 15mm. Temporal patterns were fully filtered. Runoff coefficients used are shown in Table 4-2.

Table 4-2 Runoff Coefficient for ARI Events

ARI Event	Runoff Coefficient
5 Year	0.25
100 Year	0.60

RORB parameter files were created and made available with the RORB model to BRCC.

4.2 RORB Model Reconciliation

The RORB models were reconciled to match the 100 year ARI peak flow estimates from the Rational Method calculations. This was achieved by varying the kc parameter. Kc parameters are shown in Table 4-3.

Figure 4-2 shows hydrographs from the RORB model for the 100 year ARI 2 hour event (broadly the critical duration throughout the system).

Table 4-3 RORB model reconciliation and parameters

RORB detail		Q100yr (m3/s) Rational	Q100yr (m3/s) RORB	Kc	100yr Critical Duration
C2	Hydr0001	9.88	9.86	1.80	2h
M2	Hyd0002	9.19	9.19	2.22	2h
I2	Hyd0003	8.04	8.02	1.67	1h
J3	Hyd0004	29.64	29.64	3.30	3h
W2	Hyd0009	44.11	44.11	2.36	2h
Y2*	Hyd0012	47.14	47.13	0.95	2h
AB2	Hyd0017	23.42	23.38	1.93	1h
AH2	Hyd0020	37.23	37.25	2.12	2h
AM3	Hyd0025	46.8	46.80	1.57	2h
AN2*	Hyd0031	59.86	59.86	2.24	2h
AU2	Hyd0034	9.39	9.38	1.54	2h
AZ2	Hyd0037	8.5	8.52	1.50	1h
BB3*	Hyd0038	21.59	21.59	3.11	3h

* Drainage line outlet

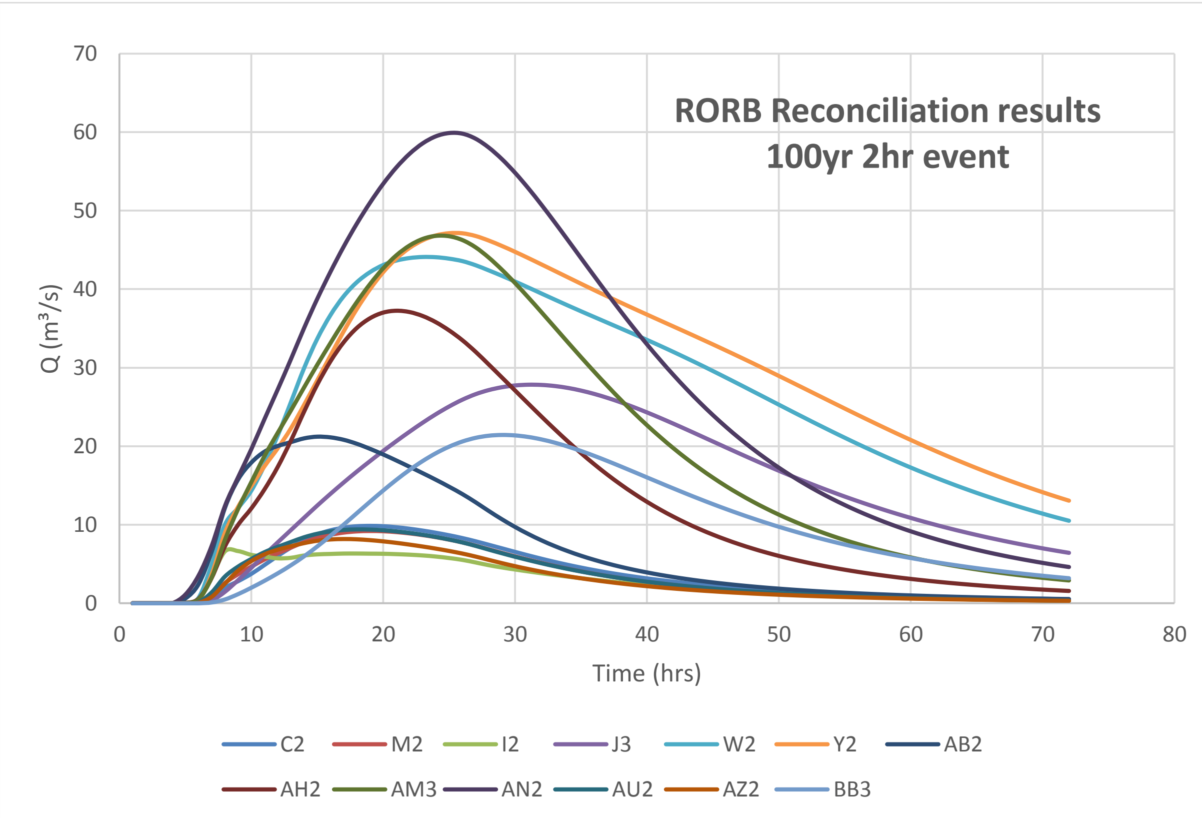

Figure 4-2 100 year ARI 2hr duration RORB Reconciliation results

4.3 RORB Model Inflows

The reconciled RORB model was then used to extract flows for the hydraulic model. 10 locations inflow were identified they are shown in Figure 4-3. Figure 4-4 and Figure 4-5 show inflow hydrographs applied in the 100yr ARI 2hr modelling which was broadly the critical duration throughout the system for that ARI. Table 4-4 shows representative peak inflows into the hydraulic modelling.

Table 4-4 RORB model peak flow results for 100yr 2hr & 5yr 6hr ARI events

RORB detail		Q100yr 2hr RORB Peak flow (m3/s)	Q 5yr 6hr RORB Peak flow (m3/s)
R2*	Hyd0005	37.0	6.9
U1	Hyd0006	6.7	1.0
V1	Hyd0007	5.8	0.9
W1	Hyd0008	8.9	1.1
X1	Hyd0010	10.7	1.2
AO1	Hyd0026	6.2	1.0
AT2	Hyd0032	6.9	1.1
Y1	Hyd0011	7.7	1.0
AW1	Hyd0036	2.9	0.5
AV1	Hyd0035	2.0	0.3

* Represented as the “external catchment” in Figure 4-5

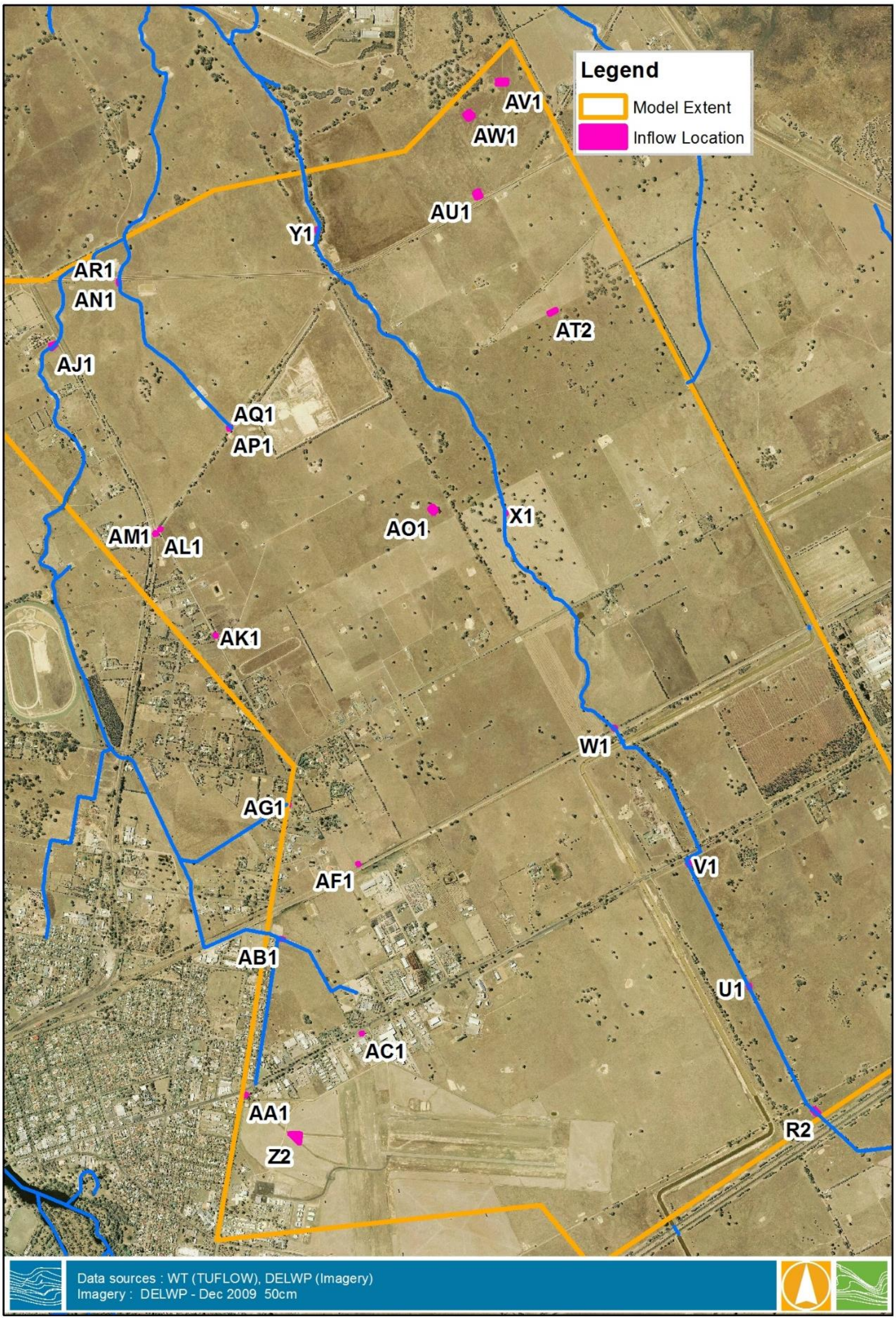

Figure 4-3 Inflow Locations

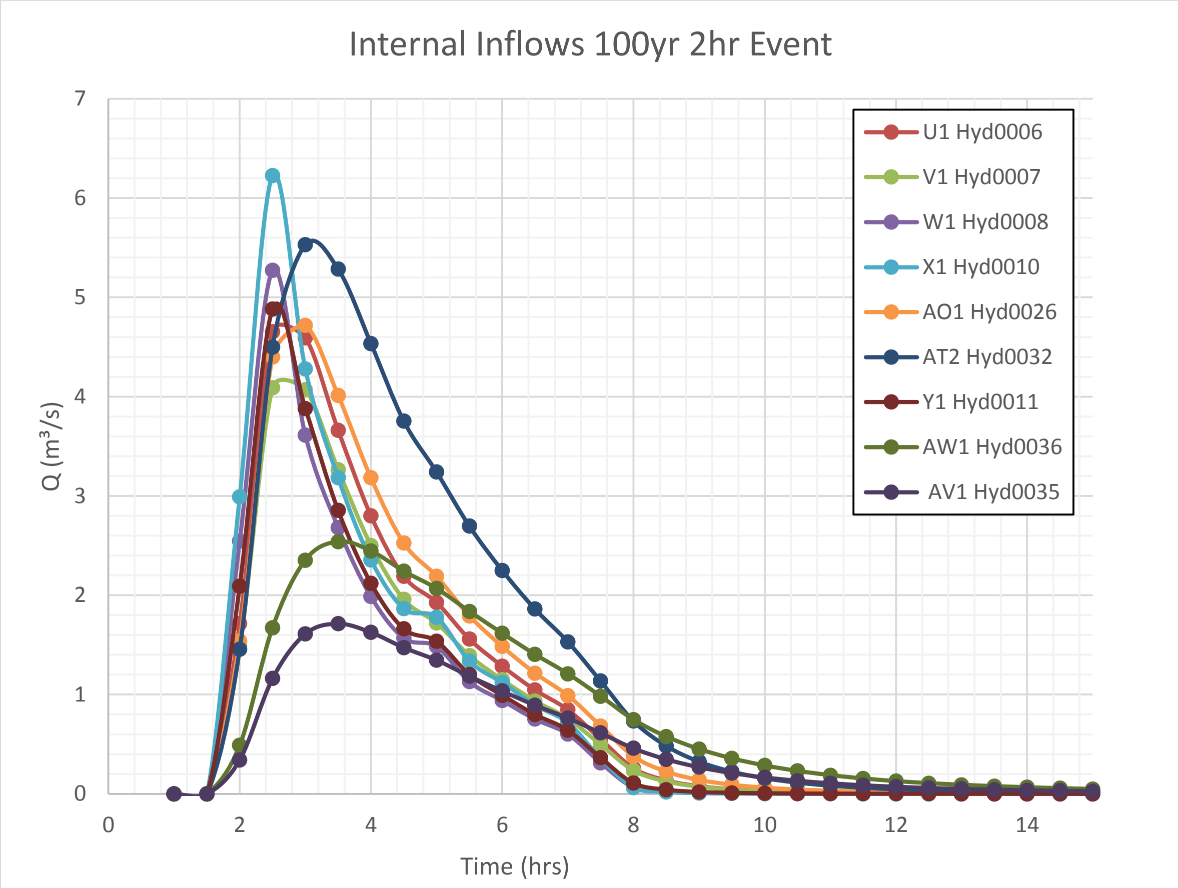

Figure 4-4 100 year ARI 2hr duration RORB Inflow Hydrographs (Internal flows)

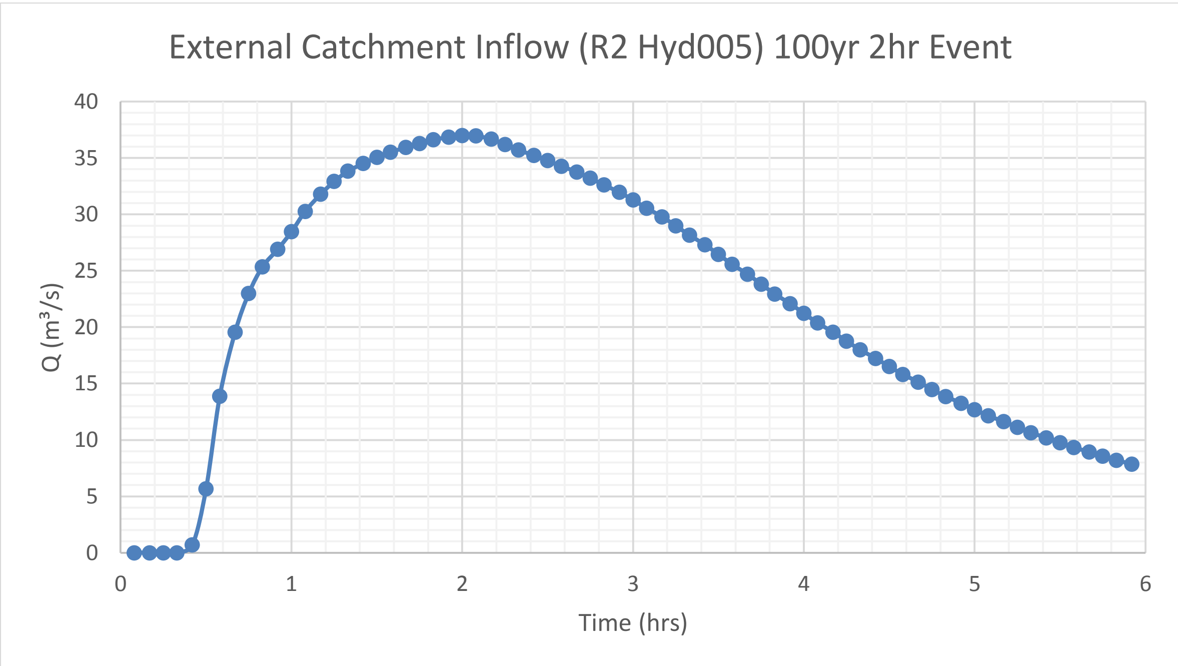

Figure 4-5 100 year ARI 2hr duration RORB Inflow Hydrographs (External Catchment flow)

5. FLOOD MODELLING

5.1 Hydraulic Model

A detailed linked one-dimensional (1D) / two-dimensional (2D) TUFLOW[1] model has been created to simulate existing flood conditions. The model will allowed for the accurate representation of the overland flow paths throughout the study area.

The model topography was compiled using 7 individual datasets these included:

- 10m_dem_mga55;
- 20m_dem_mga55;
  } Satellite data, DELWP (+/- 1-5m)
- gbcma_a3_1m_trim;
- dem_1m.txt
- fldpln_gb_1m_trim2.txt
  } LiDAR data, DELWP (+/- 100mm)
- all_south_dtm.txt
- all_north_dtm_CLIP.txt
  } UAV data, AUAV (+/- 100mm)

Preference was applied to LIDAR with this data supplemented by the UAV data collect by Australian UAV. Small areas not covered by either of these data sets were supplemented by satellite data. A review of the first pass model runs showed the areas represented by satellite data did not get wet and therefor didn't add any error to the overall results. A grid resolution of 4 m^2 was adopted to ensure adequate detail of the topography could be described. At the data boundaries (e.g. between LiDAR and the UAV datasets) some small discontinuities were observed. Where this was observed, the two datasets were smoothed out (interpolated) to insure overland flow was able to be accurately represented.

Manning's roughness values were adopted from Melbourne Water's Flood Mapping and Mitigation Technical Specifications and Requirements document. 'HQ' boundaries were used to convey overland flow out of the catchment in a steady manner.

1D networks such as underground pipes, and major crossings were incorporated in the model build. Pipes were modelled as 1D links using the MapInfo dataset provided by BBRC. This data was heavily supplemented by survey from EDM Group. The key waterway crossings were modelled using the structure details provided by EDM Group.

100 and 5 year ARI overland flow hydrographs determined though the RORB modelling mentioned within this report were input into the TUFLOW model at the ten inflow locations mentioned previously. Hydrology from the events shown in Table 5-1 were run in the TUFLOW under existing and mitigated conditions. The TUFLOW model setup is shown in Figure 5-1.

Table 5-1 Events and scenarios modelled in this study

Condition	ARI	1hr	2hr	4.5hr	6hr	12hr
Existing Conditions	100	✓	✓	✓	✓	✓
	5	✓	✓	✓	✓	✓
Mitigated conditions	100	✓	✓	✓	✓	✓

The results presented in this report are the worst flooding seen in all the conditions modelled (results have been enveloped together).

[1] TUFLOW is a standard hydrodynamic modelling package used extensively by Melbourne Water to undertake urban flood investigations.

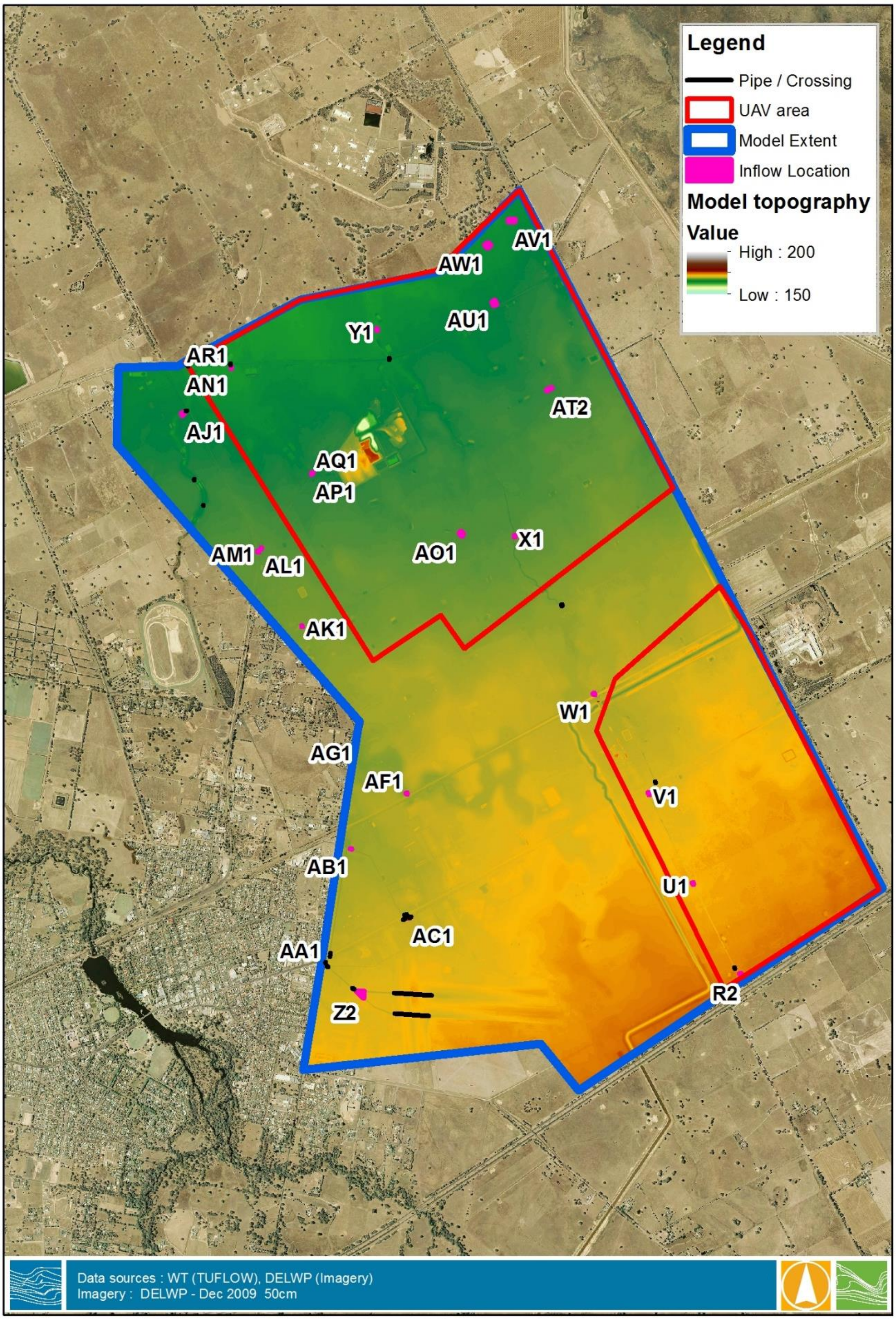

Figure 5-1 TUFLOW Model Setup

6. EXISTING CONDITIONS FLOOD MODELLING RESULTS

6.1 Overview

Flood modelling results were produced from south of the Hume highway through to Link Road about 5 kilometres north east of Benalla's CBD. The main focus of the investigation was the Kennedy Creek floodplain. The northern section of the Eastern Main drain system was included in the model to analyse if any interaction between the systems occurred. Broadly speaking, they were shown to be independent. Flood modelling results from northern sections of the Eastern Main Drain have been covered in the study maps and should not be used to estimate flooding in that section of the system. Preliminary feedback from BRCC Engineers suggested the flood model would need to be extended north to accurately represent flooding in this area.

100 year and 5 year ARI flood extents are shown in Figure 6-1. Both flood extents are quite similar reflecting the flat nature of the floodplain. Between the Hume highway and the railway line, flow paths are wide and shallow (200-400 mm deep). Around the northern boundary of this area, the flow path is significantly constricted as it flows past the Mokoan Channel syphon feature. Water tends to back up in this area, with the railway effectively acting as a defacto retarding basin, stopping some flood water from moving north.

Flood water is shown to impact Sydney Road in both 100 year and 5 year ARI event. This is expected as advice from VicRoads at the beginning of the project suggested the road was regularly cut by flood water. Historic flood levels from the VFD were compared to 100 year ARI levels. The two recorded levels between the Hume Highway and Sydney road were reasonably accurate sitting

North of the railway line some flood water flows west towards town stopping at the western boundary of the current industrial estate. However, the majority of the flow moves north towards Murray's Road, again flood water tends to back up behind the raised road feature. Flood depths on the southern side of Murrays road are deep, >1 m. Flood levels and extents in this area were noted to be "highly accurate" by local resident and farmer Ken Jaldous. Ken lived on the Kennedy Creek floodplain during the devastating 1993 flood event and suggested the 100 year ARI mapping was millimetre perfect at his property when compared to that event.

North of Murrays Road to a point level with the Reuse Depot (off Old Farley Road) flow on the floodplain is again broad and shallow (100-300 mm). North of the Reuse depot, flow paths become more constricted and deeper, before backing up behind Link Road. This area marks the northern boundary of the flood mapping project.

Flood maps for the 100 year ARI event for following parameters (show below) are shown on the following pages. Results presented equate to the worst flooding observed in the 1, 2, 4.5, 6 and 12 hour duration 100 year ARI events. Maximum results from each of these modelling runs were enveloped to produce the following maps:

- Peak Flood Depth (m) - Figure 6-2;
- Peak Water Surface Elevation (m AHD) - Figure 6-3;
    - These results could be thought of as the "flood levels" determined in the study;
- Peak Flood Velocities (m/s) - Figure 6-4; and
- Flood Hazard (i.e. the greater of Velocity x Depth (m^2/s) or depth (m)) - Figure 6-5;
    - Further discussion of flood hazard criteria can be found in the Enterprise Park drainage strategy.

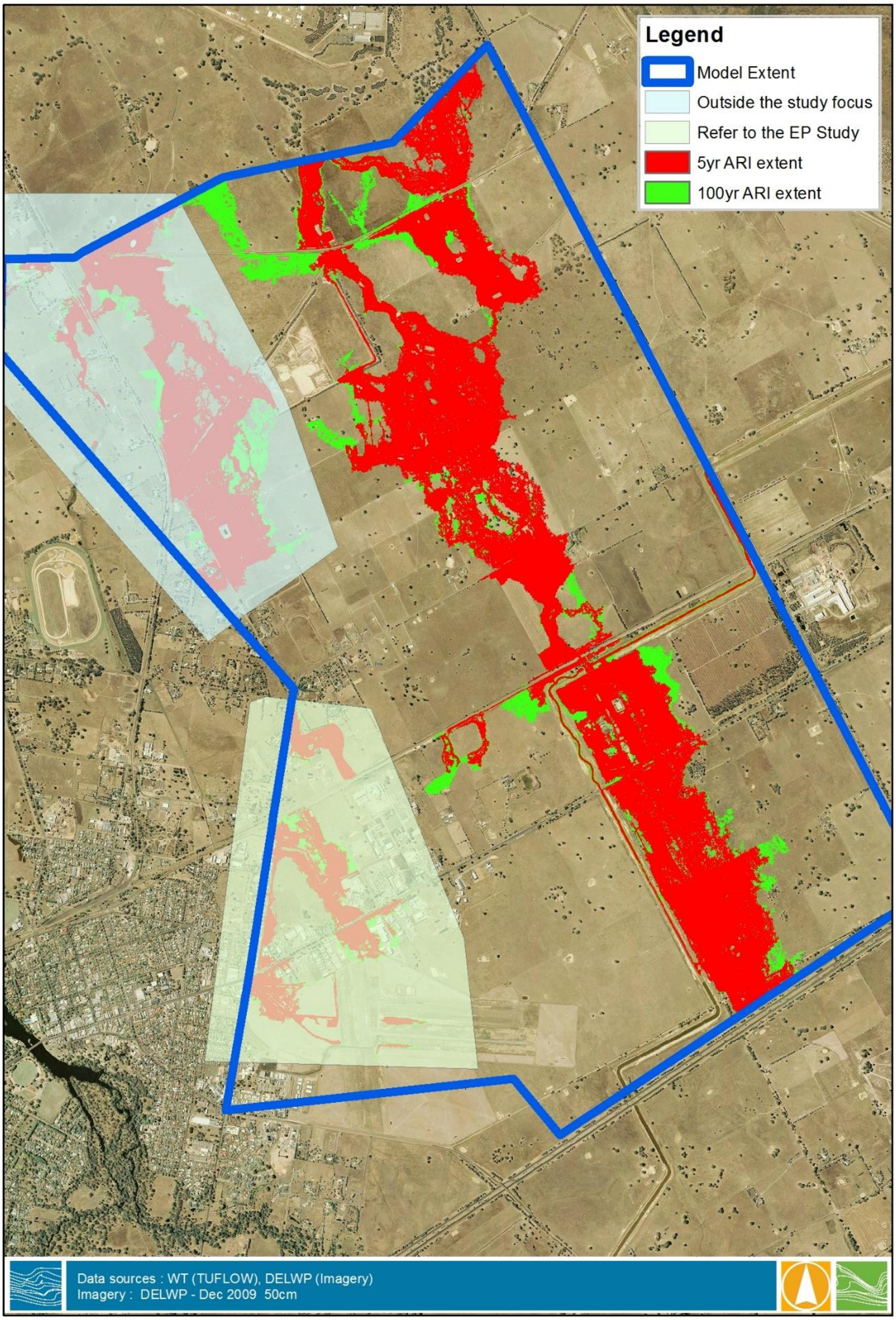

Figure 6-1 Flood Extents 5 and 100 year ARI flood extents – Study Area

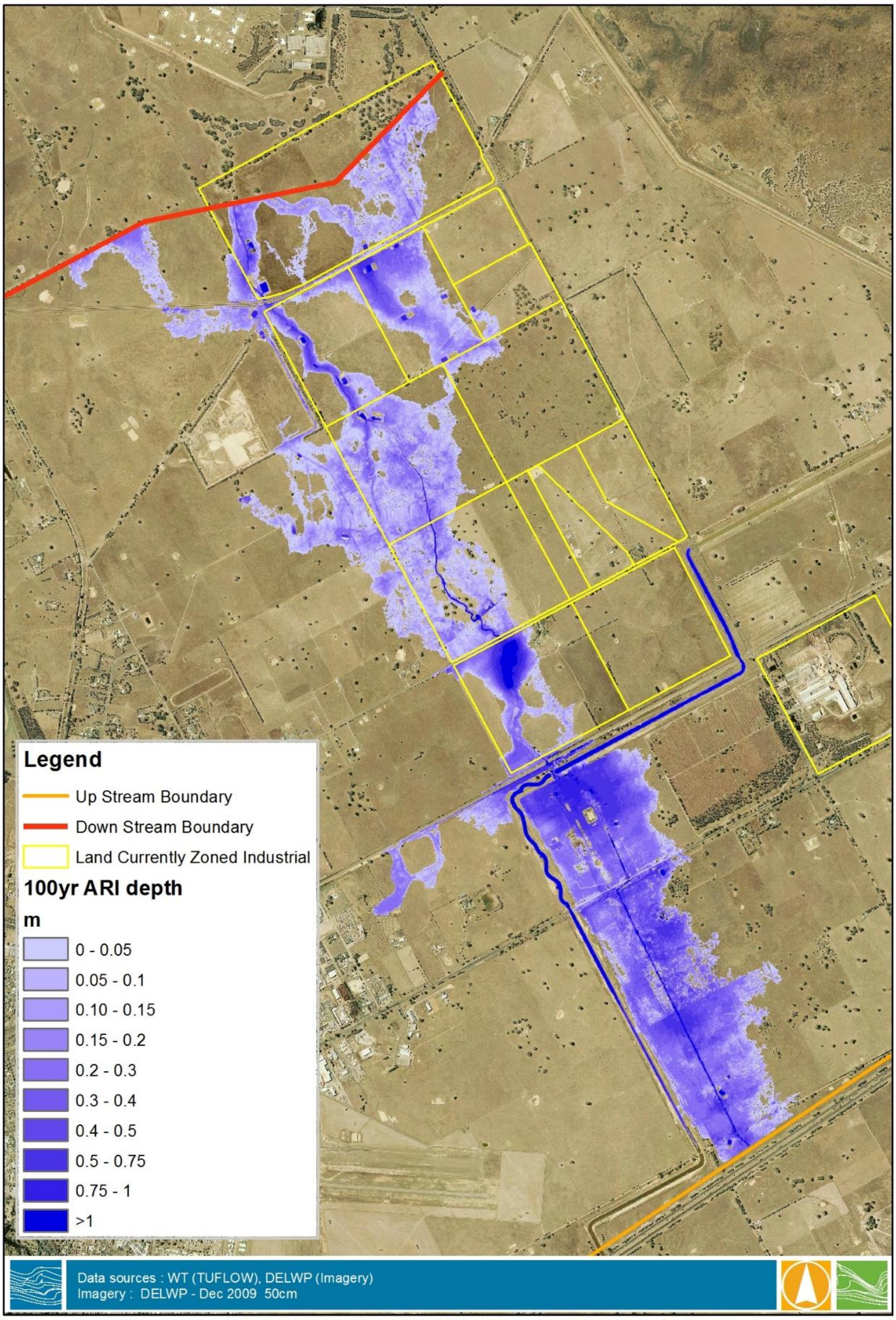

Figure 6-2 Flood Depth 100 year ARI event– Study Area

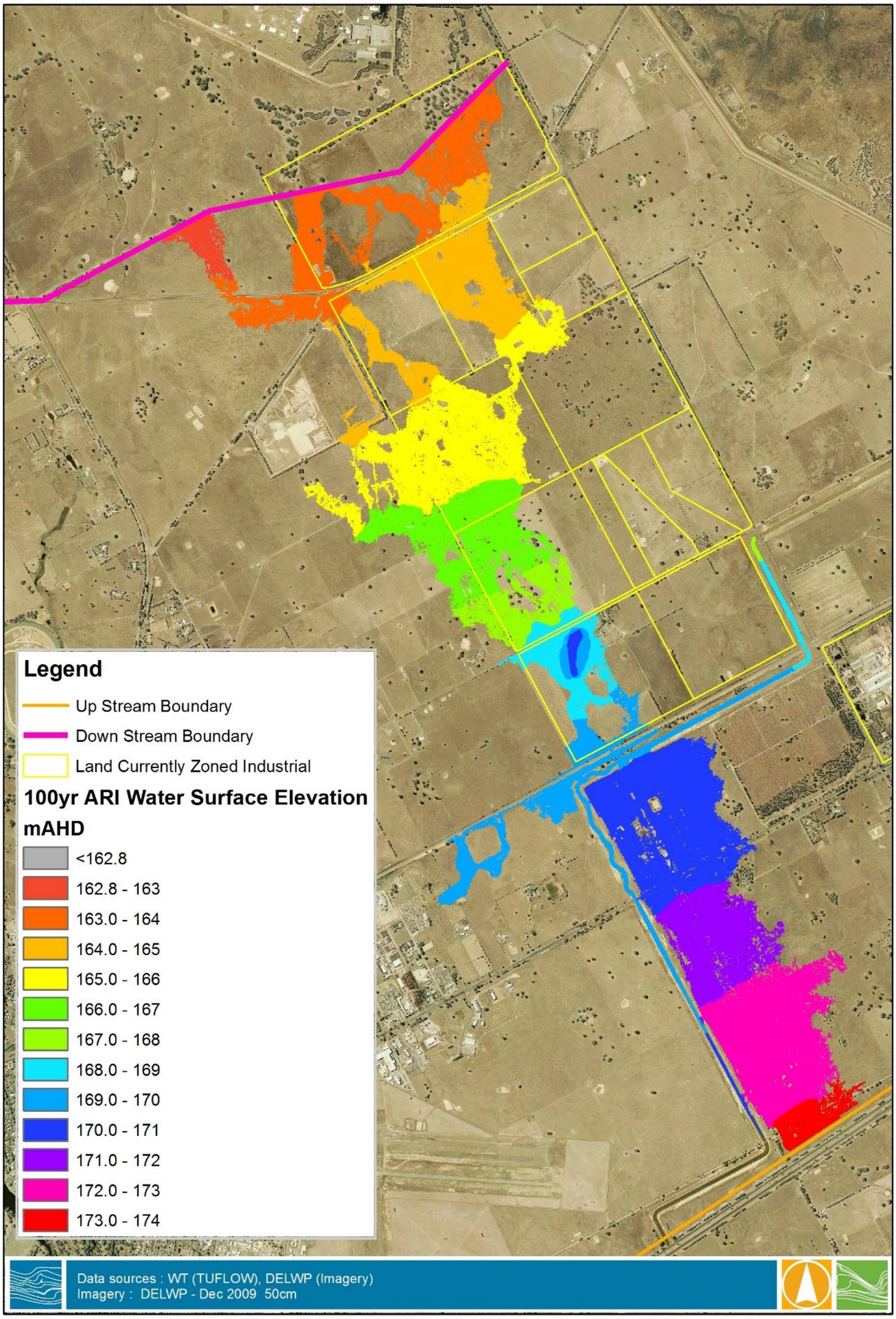

Figure 6-3 Flood Levels (Water Surface Elevation) 100 year ARI event– Study Area

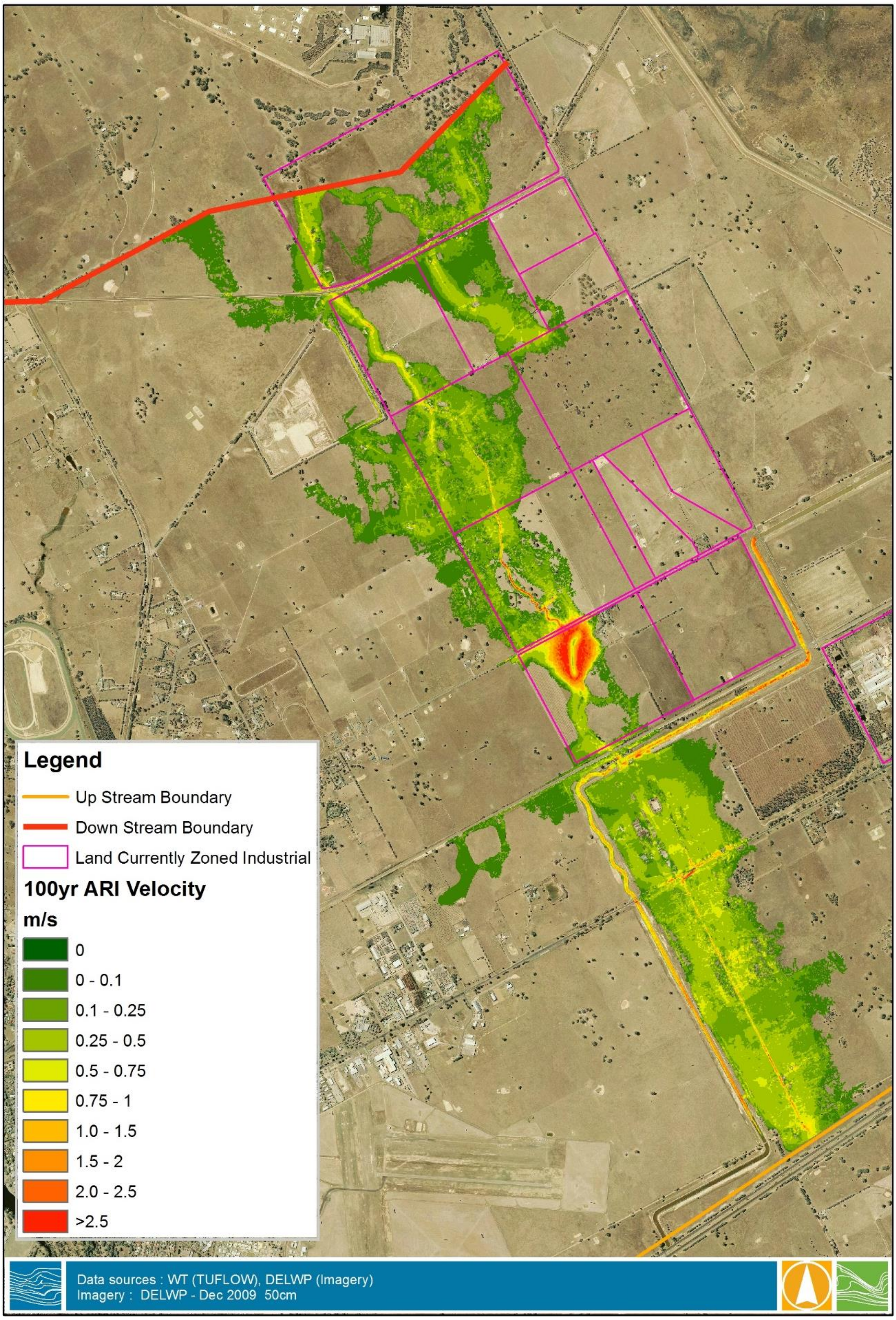

Figure 6-4 Flood Velocity 100 year ARI event– Study Area

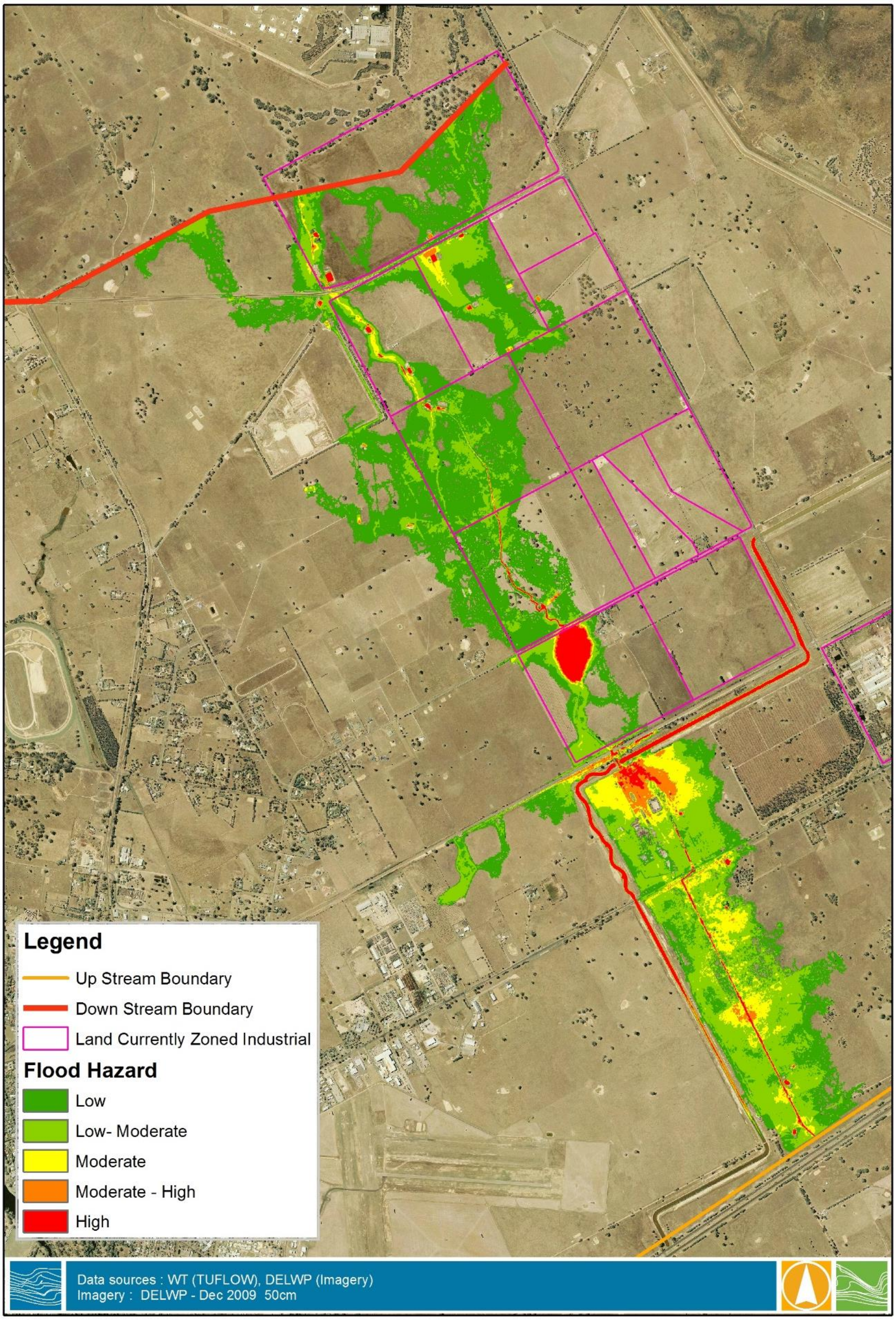

Figure 6-5 Flood Hazard 100 year ARI event– Study Area

6.2 Result Checks

Flood modelling results were provided to VicRoads, Goulbourn Broken CMA, BRCC staff and community representatives for comment. All stakeholders who responded suggested the mapping was accurate.

Guy Tierney of the GBCMA asked to have the results checked against the 1993 spot levels in the Victorian Flood database. The 1993 flood event has been estimated by others as equivalent to a 1 in 100 year ARI event. 6 levels exist within the study area.

At the upstream end of the study area (between the Hume freeway and Sydney road) flood levels were about 200 mm higher than the 1993 flood levels. While between Sydney Road and the railway crossing results were about 500 mm lower than 1993 flood levels. North of the railway line at Murray's Road the hydraulic model results did not extend to the recorded flood level (boundary of the flood extent was 8 m away), Further north adjacent to the refuse depot the hydraulic models flood level was within 200 mm of that recorded 1993.

Overall given the high level nature of the investigation the flood modelling results are considered fit for purpose

6.3 100 year ARI results within the land zoned industrial

The major diver of this study was to get a better understanding of flooding within the land North East of the Benalla which is currently zoned for industrial land use but is currently used for primary production (farming).

The flood modelling results showed approximately half of this area is subject to flooding from the Kennedy Creek. It is noted that without the railway line and the Mokoan Channel syphon feature, flooding of this land would likely be more significant. While the extent of flooding is significant, flood depths and velocities are not high, suggesting fill could be placed in the floodplain without significant impacts.

It is envisaged that while flooding would place some constraints of development inside this area, however, mitigation options may be available to allow some land to be developed. Any development would be subject to controls set by the GBCMA and would require further modelling to be realised.

7. MITIGATED CONDITIONS FLOOD MODELLING

7.1 Overview

As part of the project scope, Water Technology undertook a desktop analysis of available mitigation options for the Kennedy Creek floodplain. Mitigation was focused on;

- Relieving existing flooding at Sydney Road; and,
- Reducing flooding inside the land proposed for industrial development.

Each of the options considered are discussed below. These options were presented to the project steering committee November 2014. Advice was provided to Water Technology to further progress the option of a diversion into Kennedy Creek in February 2015.

7.1.1 Retarding basin

Constructing a retarding basin upstream of Sydney Road off-line from Kennedy Creek, and incorporate a high-flow diversion from the creek to the basin was considered as one option to reduce flooding. This option would result in a slow discharge outlet to the Creek at a controlled rate so as not to exceed the capacity of the primary creek channel.

There are a range of locations available upstream of Sydney Road with potentially suitable land, however there are two main points to consider regarding the location:

1. The closer to Sydney Road the basin is sighted, the more catchment it can retard, and therefore reduce not only flooding to Sydney Road, but also the flood overlay downstream within potential industrial land, thereby improving the value of said land;
2. The closer to the Hume Freeway that the basin is constructed, more land between Hume Freeway and Sydney Road may be able to be developed as industrial land as the flood overlay could be reduced in this area by having the retarding basin upstream of it.

Figure 7-1 shows two potential locations for basin features. These considerations would not only impact the location of the basin, but also the size of the basin, as a greater catchment will require a larger basin.

Design considerations included:

- Proximity to Sydney Road
    - The closer the basin is to Sydney Road, the easier it will be to use the existing culverts under Sydney Road for Kennedy Creek as a controlled discharge point for the basin – saving on cost and time during construction.
- Water Re-use;
    - Water collected in the retarding basin could be harvested and reused within the industrial estate e.g. as construction water during development or for plant operations, etc.

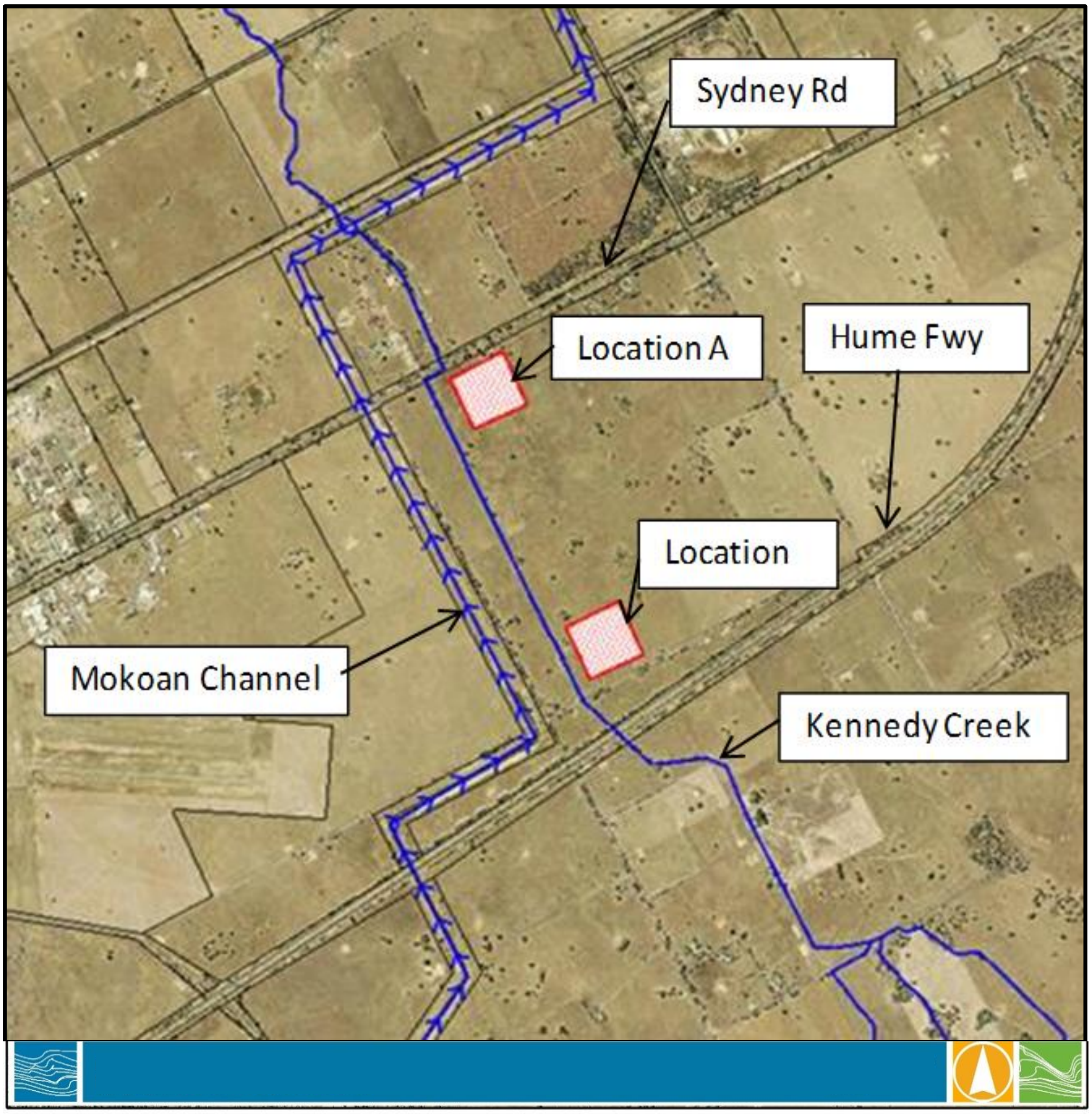

Figure 7-1 Mitigation option analysis – Retarding Basins

7.1.2 Mokoan Channel

The Mokoan Channel could be used for 3 purposes, if Kennedy Creek is diverted to the channel upstream of Sydney Road;

1. Conveyance channel for high flows from Kennedy Creek to the Winton Wetlands;
2. Retarding basin for high flows from Kennedy Creek, with the flows discharged back to Kennedy Creek just south of the rail line at a controlled rate; or,
3. A combination of the above.

The intent with this option was to allow a continuous low flow through the channel from the retarding area to the wetlands, so as not to disrupt the existing function of the wetlands, and only discharge high flows back into Kennedy Creek as required. Figure 7-2 shows concept for the retarding basin within the channel.

A Manning's calculation of the channel capacity indicates it is in the order of 120 m^3/s, with the flows upstream of Kennedy Creek in the order of 40 m^3/s, suggesting there could be capacity for the Kennedy Creek flows within the Mokoan Channel. One potential challenge in this option is the capacity of the syphon feature near the railway crossing were the Mokoan Channel turns from flowing north to east crossing the Kennedy creek floodplain. No structure details were collected by EDM group during their feature survey.

Ultimately this mitigation option would need to demonstrate that:

- The rail line is unaffected by the proposed works;
- The channel itself would not flood Sydney Road;
- The drainage of the natural catchment of the channel will not be affected by this proposal;
- The weir level set (in the instance of a retarding basin) does not cause flooding/overtopping of the channel banks upstream; and,
- The diverted flow was accepted by the Winton Wetlands committee of management.

Many options exist to achieve this design criteria, however Water Technology modelling only looked at proving the concept was viable, with the assumption that further work would be required to refine any option trialled.

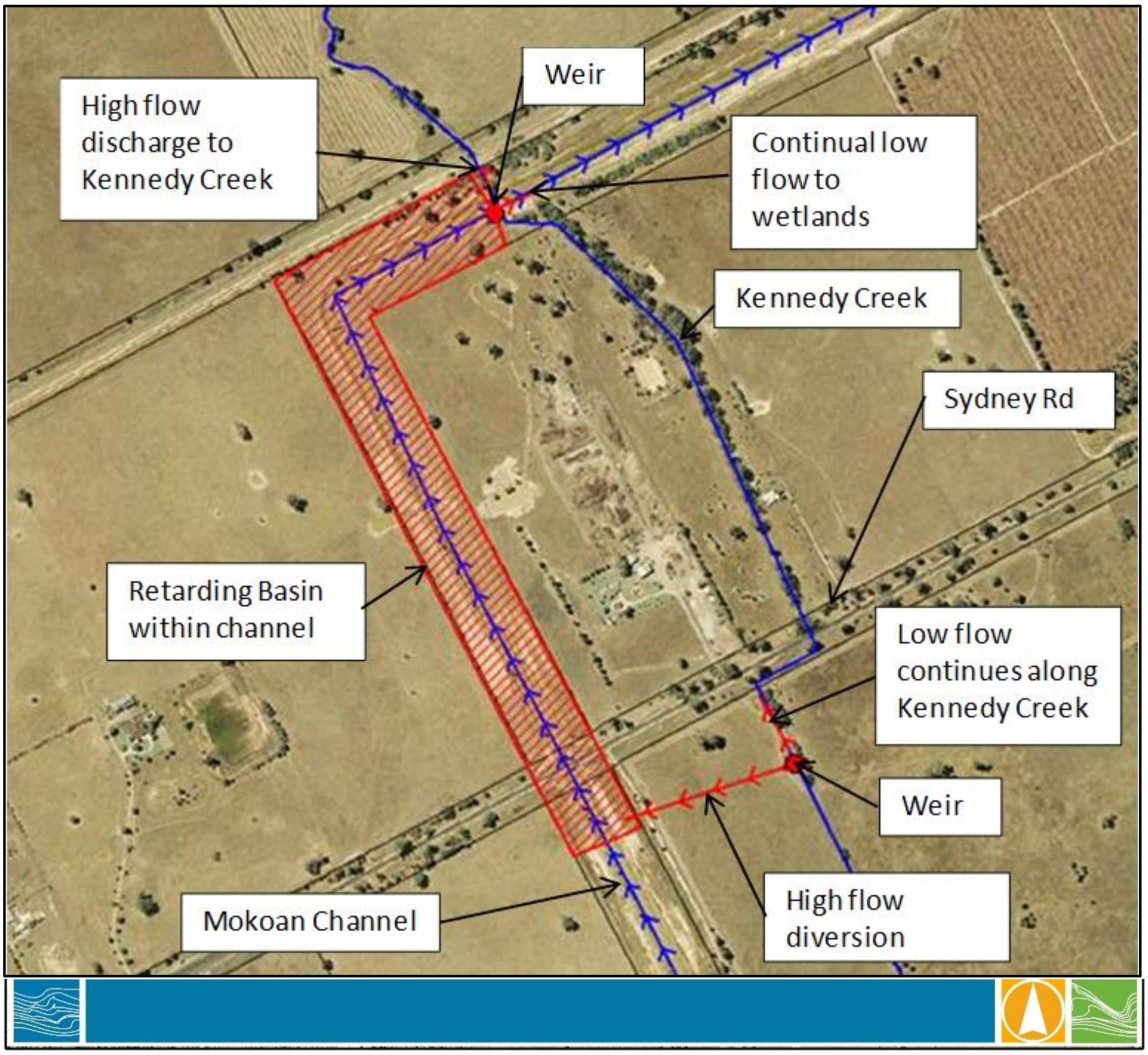

Figure 7-2 Mitigation option analysis – Diversion to Kennedy Creek

7.1.3 Alter Sydney Road/ and/or the culverts under it

The final option is to either raise and/or increase the capacity of the culverts under Sydney Road to allow Kennedy Creek to drain more freely. This could mitigate the flooding on Sydney Road, but would do little to reduce the flood overlay on the industrial land downstream of Kennedy Creek. It would also likely be the most expensive option, disrupt traffic flows along Sydney Road, and there may not be sufficient space within the road reserve to increase the level of the road. For these reasons, it was the least desirable option.

7.2 Preliminary Mitigation modelling results

7.2.1 Discussion

As discussed it was resolved by the steering committee to further investigate the diversion to the Mokoan channel mitigation option. Initial mitigation modelling runs trailed focused on diverting flood water through the southern road reserve along Sydney Road. Unfortunately the reserve area wasn't wide enough to achieve significant reductions in flooding at Sydney Road. The next iteration of the modelling process looked at using the Hume Freeway road reserve, again the option could not be made to work without using some privately owned land.

The mitigation modelling results adopted in this report involve acquiring about 13 ha of land immediately north of the Hume Freeway. Under this scenario, this land would remain available to the land owner for grazing. Equally the same arrangement could be implemented closer to Sydney Road.

The works shown in Figure 7-3 were tested in the hydraulic model. They included modest bunding (~500 mm high), a diversion channel (15 m wide) and a low flow pipe arrangement through the bunding (3xΦ900 mm RCPs). Using this treatment resulted in around 90% of the external catchment flows being diverted into the Mokoan Channel.

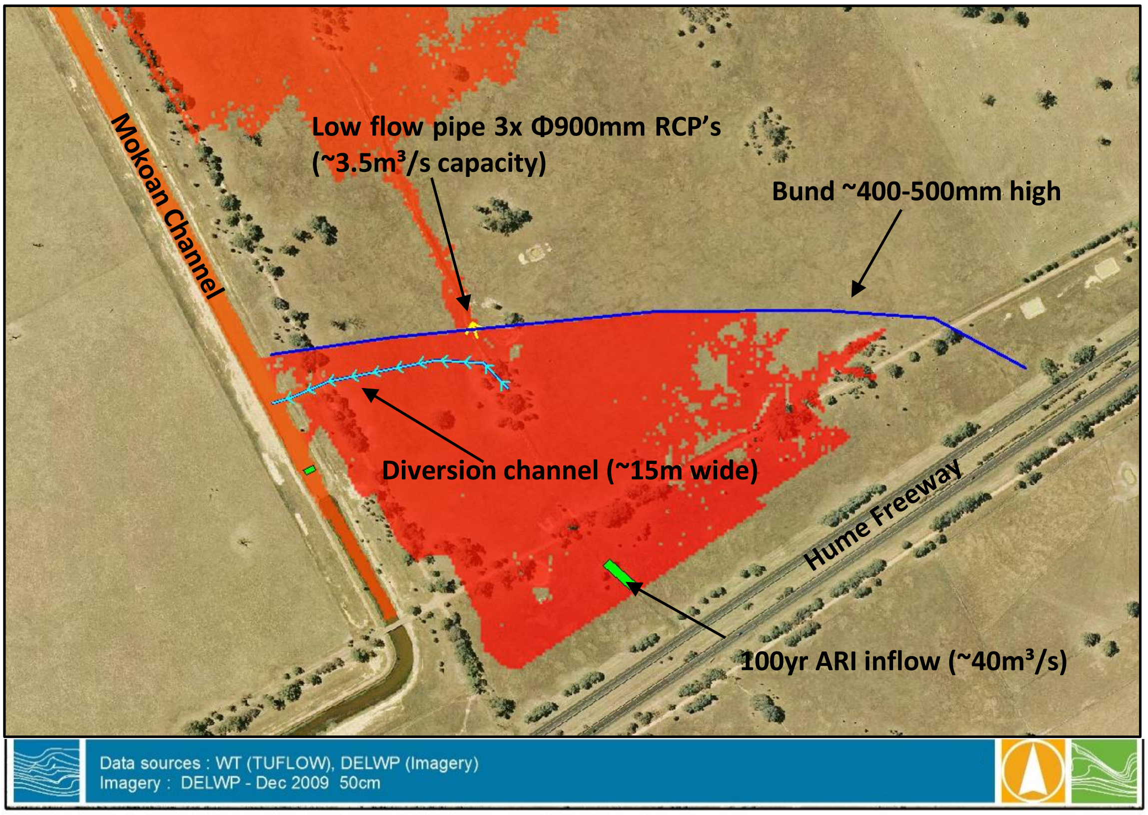

Figure 7-3 Preliminary mitigation option tested in hydraulic model

Adopting the aforementioned conditions resulted in significantly less flooding between the Hume Freeway and the railway crossing (as shown in Figure 7-4). Unfortunately it did not significantly reduce flooding north of the railway line within the industrial zoned land. Flooding of Sydney Road is managed with this solution with all flooding of the road practically eliminated.

Figure 7-5 shows the change in flood levels between the Hume freeway and the Railway line. Regions shaded in green show area where flood levels have been reduced. Yellow and orange regions are where flood levels have increased. Through the area shown in Figure 7-5, flood levels are largely reduced by 200 mm+. The exception to this is behind the bunded area and inside the Mokoan Channel.

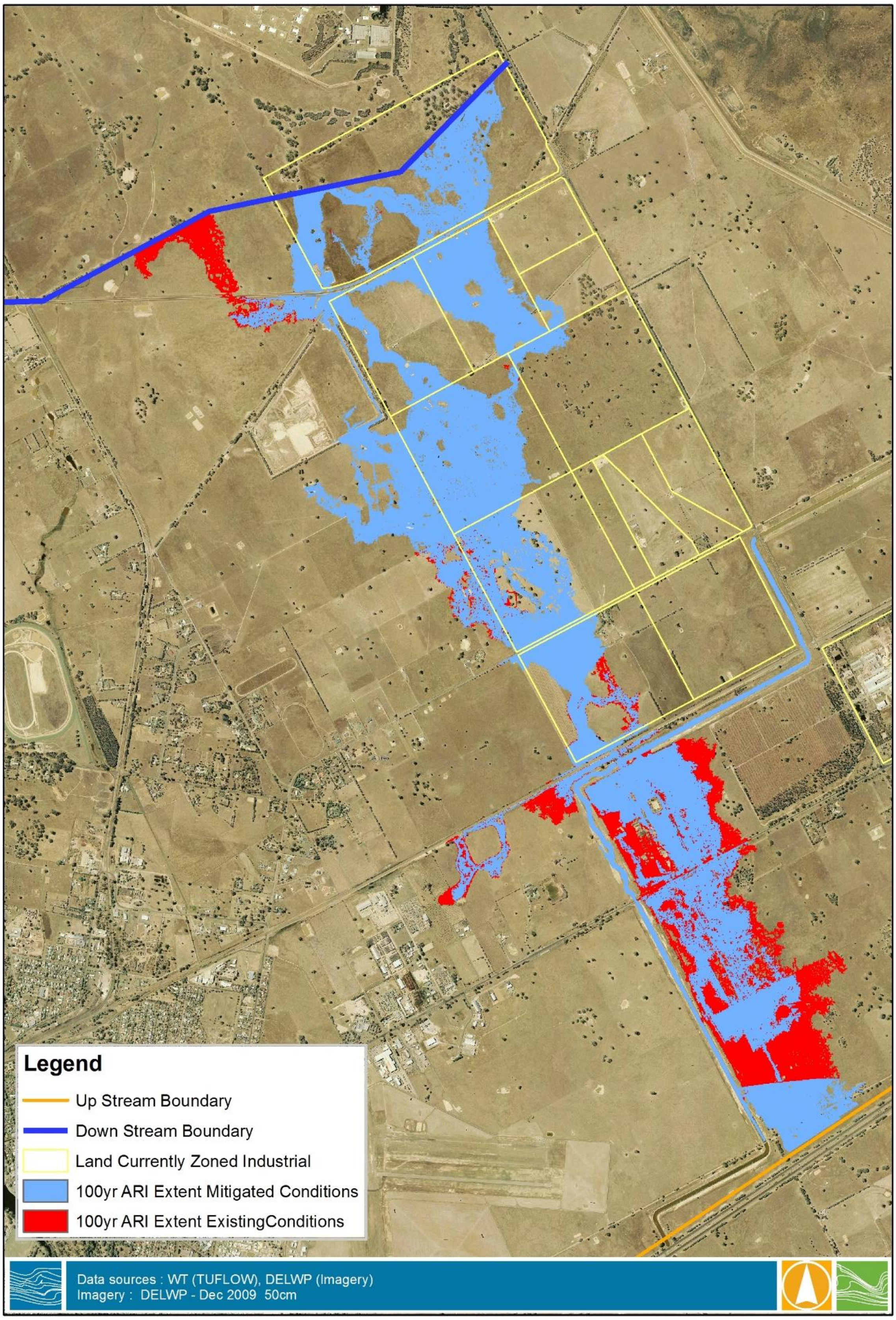

Figure 7-4 Flood Extent comparison 100 year ARI event – Existing & mitigated conditions

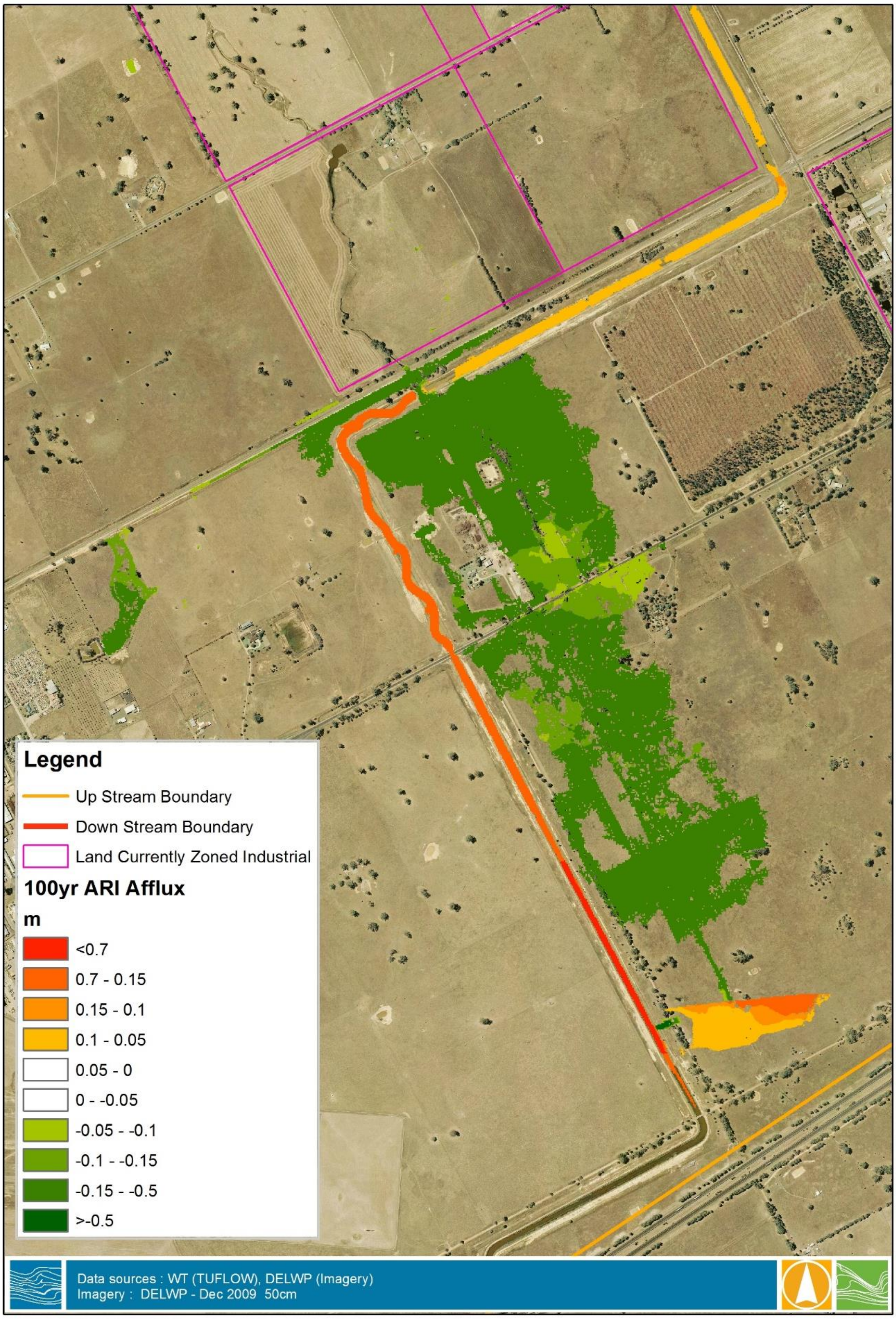

Figure 7-5 Flood Level difference plot (Afflux) - 100 year ARI event– Study Area

8. SUMMARY & CONCLUSION

Hydrologic and hydraulic analysis by Water Technology has been undertaken to describe the current flooding conditions on the Kennedy Creek floodplain from the Hume Freeway through to Link Road 5 km north of the Benalla CBD.

Flood modelling results were presented to various stakeholders for comment. Generally the flood mapping been accepted as an accurate description of flooding inside the study area. Flood maps produced showed:

- Broad shallow flooding between the Hume freeway and the railway line crossing;
- Breakout flows moving west towards the town from the railway / Mokoan channel syphon area;
- Deeper more concentrated flows between the railway line and Murray Road, with significant ponding behind Murray Road;
- Shallow broad flooding between Murray Road and the refuse depot; and,
- More concentrated flows from the reuse depot to the study boundary.

The major diver of this study was to get a better understanding of flooding within the land North East of the Benalla which is currently zoned for industrial land use but is currently used for primary production (farming).

The flood modelling results showed approximately half of this area is subject to flooding from the Kennedy Creek. Flood depths and velocities inside the region are not high suggesting fill could be placed in the floodplain without significant impacts. Flooding would place some constraints of development inside this area, but mitigation options may be available to allow land to be developed.

Several options were presented to BRCC to mitigate flooding on the Kennedy Creek floodplain, with options focused on reducing flooding in the land zoned industrial and stopping Sydney Road being inundated.

It was resolved to investigate diverting flood flows into to the Mokoan Channel as mitigation option. This modelling showed that significant reductions (200 mm+) in flood levels could be achieved between the Hume Freeway and the railway line. North of this area only small changes in the maximum flood extents were observed. This result reflected original conclusions that the Mokoan Channel syphon and the railway crossing provide significant attention for the land to the north already.

APPENDIX A RORB MODELLING DETAIL

Catchment File:

```
Kennedy Ck - 0
C RORB_GE 6.15
C WARNING - DO NOT EDIT THIS FILE OUTSIDE RORB TO ENSURE BOTH GRAPHICAL AND CATCHMENT DATA ARE COMPATIBLE WITH EACH OTHER
C THIS FILE CANNOT BE OPENED IN EARLIER VERSIONS OF RORB GE - CURRENT VERSION IS v6.15
C
C Kennedy Ck - 0
C
C #FILE COMMENTS
C  2
C File created using MiRORB version 1.2
C Original CATG file created on 27/05/2014 at 15:41:32
C
C #SUB-AREA AREA COMMENTS
C  1
C Sub-area areas in km2
C
C #IMPERVIOUS FRACTION COMMENTS
C  0
C
C #BACKGROUND IMAGE
C  T  F M:\Jobs\3000-3099\3014_Enterprise_Park_Developme\Analysis\RORB_KennedyCk\KennedyCk_Ex.wmf
C
C #NODES
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C    1    69.244    14.391    1.000 1 0   55 A     1.179    0.050  0  0
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C    2    67.541    17.328    1.000 1 0   56 B     0.699    0.050  0  0
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C    4    65.189    24.967    1.000 1 0   61 D     0.683    0.048  0  0
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C    6    63.015    34.887    1.000 1 0   66 F     1.268    0.050  0  0
C
C    7    71.345     9.867    1.000 1 0   68 G     0.782    0.050  0  0
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C     19.084
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C     17.628   17.904   18.222   18.306   18.414   18.599   18.983   19.010   19.118   19.433   19.402
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C     64.997   64.605   64.181   63.516   62.868
C     24.443   24.123   24.163   23.990   23.963
C  11 D1-D2     61   62     0 5 0    0.002    1.721   1  0
C     61.963
C     24.239
C  12 D2-D3     62   63     0 1 0    0.225    0.677   3  0
C     61.730   61.465   61.389
C     24.212   24.232   24.432
C  13 D3-E2     63   65     0 2 0    0.942    0.318   10  0
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C 60.689 60.481 60.414 60.235 60.094 59.999 59.130 59.010 58.913 58.987
C 24.920 25.306 25.496 26.223 27.213 27.445 27.801 28.238 28.569 29.349
C 14 E-E1 5 64 0 1 0 1.168 1.855 5 0
C 63.727 63.263 62.335 60.990 60.270
C 30.571 30.117 30.224 30.224 30.064
C 15 E1-E2 64 65 0 5 0 0.002 0.000 1 0
C 59.051
C 30.017
C 16 E2-F2 65 67 0 2 0 0.850 0.002 5 0
C 58.820 57.995 57.587 57.114 56.691
C 30.195 31.490 32.171 32.886 32.794
C 17 F-F1 6 66 0 1 0 1.580 0.634 2 0
C 62.536 61.223
C 34.299 33.712
C 18 F1-F2 66 67 0 5 0 0.002 0.079 1 0
C 56.063
C 33.716
C 19 G-G1 7 68 0 1 0 0.660 3.288 1 0
C 70.187
C 10.030
C 20 G1-H2 68 70 0 1 0 1.009 1.840 7 0
C 67.522 67.090 66.770 66.506 65.977 64.937 64.641
C 10.484 10.444 10.564 10.617 10.951 11.364 12.538
C 21 H-H1 8 69 0 1 0 0.679 0.571 4 0
C 65.537 65.137 64.785 64.553
C 9.037 9.970 11.064 11.971
C 22 H1-H2 69 70 0 5 0 0.002 0.000 1 0
C 64.392
C 12.627
C 23 H2-I2 70 72 0 1 0 1.501 0.336 11 0
C 64.227 63.800 63.286 62.910 62.582 62.426 62.306 62.276 62.285 62.392 62.264
C 12.861 12.724 12.661 12.969 13.209 13.553 14.253 14.723 15.498 17.761 19.922
C 24 I-I1 9 71 0 2 0 0.723 0.334 6 0
C 61.882 61.995 61.999 61.915 61.797 61.794
C 16.698 17.885 18.029 18.450 19.070 19.129
C 25 I1-I2 71 72 0 5 0 0.002 0.767 1 0
C 61.890
C 21.153
C 26 I2-J2 72 74 0 2 0 2.278 0.236 40 0
C 61.115 61.023 60.833 60.642 60.488 60.378 60.245 60.151 60.011 59.874 59.565 59.337 59.180 59.121 59.072
59.010 58.917 58.612 58.512 57.980 57.676 57.530 57.259 57.111 57.003 56.874 56.750 56.616 56.481 56.271 56.131
56.008 55.822 55.607 55.361 55.256 55.138 55.052 55.058 55.087
C 22.010 22.244 22.700 23.172 23.548 23.798 24.111 24.363 24.570 24.803 25.296 25.418 25.487 25.585 25.639
25.657 25.676 25.689 25.718 26.150 26.453 26.678 27.270 27.604 27.867 28.180 28.721 29.182 29.728 30.299 30.702
31.113 31.423 31.768 32.190 32.389 32.604 32.824 32.954 33.145
C 27 J-J1 10 73 0 1 0 1.238 0.092 1 0
C 56.903
C 29.529
C 28 J1-J2 73 74 0 5 0 0.002 0.000 1 0
C 55.110
C 33.245
C 29 J2-J3 74 84 0 2 0 0.017 0.078 1 0
C 55.085
C 33.345
C 30 F2-J3 67 84 0 2 0 0.202 0.125 2 0
C 55.625 55.437
C 33.531 33.717
C 31 K-K1 11 75 0 2 0 0.526 0.108 22 0
C 61.335 61.312 61.236 61.195 61.166 61.134 61.080 61.039 60.969 60.962 60.905 60.816 60.768 60.765 60.781
60.774 60.739 60.704 60.689 60.695 60.746 60.950
C 7.915 7.989 8.053 8.138 8.297 8.387 8.472 8.504 8.737 8.960 9.124 9.252 9.437 9.628 9.830 10.026
10.159 10.244 10.376 10.599 10.806 11.050
C 32 K1-L2 75 77 0 2 0 1.290 0.423 17 0
C 61.051 61.083 61.158 61.192 61.209 61.213 61.269 61.272 61.041 60.680 59.299 59.089 58.918 59.049 59.168
59.299 59.417
C 11.245 11.378 11.496 11.622 11.731 12.003 12.210 12.885 13.212 13.629 12.797 12.928 13.301 14.199 15.381
16.104 16.552
C 33 L-L1 12 76 0 1 0 0.621 0.398 1 0
C 58.851
C 14.355
C 34 L1-L2 76 77 0 5 0 0.002 0.565 1 0
C 59.355
C 16.573
C 35 L2-M2 77 79 0 2 0 0.756 0.192 8 0
C 59.129 58.891 58.669 58.351 58.208 58.038 57.748 57.589
C 17.181 17.968 18.537 18.908 19.543 20.158 20.615 20.833
C 36 M-M1 13 78 0 1 0 0.793 0.208 1 0
C 57.088
C 18.451
C 37 M1-M2 78 79 0 5 0 0.002 0.000 1 0
C 57.616
C 21.338
C 38 M2-N2 79 81 0 2 0 0.796 0.177 24 0
C 57.608 57.609 57.597 57.590 57.560 57.480 57.359 57.267 57.253 57.067 57.032 57.018 56.996 56.962 56.921
56.824 56.614 56.490 56.349 56.303 56.204 56.154 56.111 56.013
C 21.545 21.979 22.162 22.237 22.376 22.621 22.871 23.030 23.078 23.414 23.537 23.780 23.933 24.211 24.410
24.750 25.361 25.512 25.605 25.690 25.928 26.090 26.144 26.207
C 39 N-N1 14 80 0 2 0 0.453 0.222 2 0
C 55.649 55.939
C 24.651 25.597
C 40 N1-N2 80 81 0 5 0 0.002 0.182 1 0
C 55.854
C 26.164
C 41 N2-O2 81 83 0 2 0 0.892 0.144 11 0
```

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C    55.835   55.725   55.588   55.385   54.952   54.918   54.908   54.688   54.668   54.598   54.458
C    26.254   26.934   27.782   28.194   29.639   30.274   30.317   30.772   30.834   30.967   31.290
C  42 O-O1      15  82     0 1 0    1.115    0.129   1 0
C    53.816
C    27.871
C  43 O1-O2     82  83     0 5 0    0.002    0.067   1 0
C    54.046
C    32.140
C  44 O2-J2     83  74     0 2 0    0.270    0.002   1 0
C    54.573
C    32.729
C  45 J3-J4     84  85     0 2 0    1.230    0.263   5 0
C    54.865   54.104   54.013   53.657   52.254
C    33.240   33.013   33.012   33.078   37.711
C  46 Q-Q1      17  88     0 1 0    2.202    0.583   5 0
C    59.949   59.264   57.790   56.135   55.140
C    37.282   36.291   35.601   36.506   37.023
C  47 Q1-J4     88  85     0 5 0    0.002    0.438   1 0
C    51.924
C    39.279
C  48 J4-P2     85  87     0 2 0    0.104    0.404   1 0
C    51.795
C    39.375
C  49 P-P1      16  86     0 1 0    0.949    0.261   1 0
C    51.790
C    36.050
C  50 P1-P2     86  87     0 5 0    0.002    0.695   1 0
C    51.408
C    39.645
C  51 P2-R2     87  90     0 3 0    0.679    0.151   2 0
C    50.325   50.232
C    39.473   39.473
C  52 R-R1      18  89     0 1 0    1.493    0.311   1 0
C    50.371
C    41.718
C  53 R1-R2     89  90     0 5 0    0.002    0.000   1 0
C    48.817
C    41.650
C  54 S-S1      19  91     0 1 0    1.312    0.223   2 0
C    49.261   49.184
C    34.960   38.235
C  55 S1-R2     91  90     0 5 0    0.002    0.000   1 0
C    48.806
C    41.635
C  56 T-T1      20  92     0 1 0    1.643    0.175   2 0
C    47.174   46.967
C    34.738   37.539
C  57 T1-R2     92  90     0 5 0    0.002    0.000   1 0
C    48.799
C    41.637
C  58 U-U1      21  93     0 1 0    1.082    0.121   1 0
C    50.174
C    46.367
C  59 U1-U2     93  94     0 5 0    0.002    0.000   1 0
C    47.171
C    47.209
C  60 R2-U2     90  94     0 2 0    0.815    0.002   7 0
C    48.775   48.707   48.196   48.130   48.120   47.945   47.867
C    41.788   41.994   43.732   43.932   43.989   44.550   44.818
C  61 U2-V2     94  96     0 2 0    0.825    0.083   1 0
C    47.146
C    47.251
C  62 V-V1      22  95     0 1 0    1.078    0.134   2 0
C    47.818   46.682
C    51.129   52.387
C  63 V1-V2     95  96     0 5 0    0.002    0.146   1 0
C    45.493
C    52.860
C  64 V2-W2     96  98     0 2 0    1.040    0.202   5 0
C    45.482   45.885   44.939   44.137   43.797
C    52.913   53.266   56.746   58.038   58.076
C  65 W-W1      23  97     0 1 0    0.504    0.256   1 0
C    43.775
C    56.962
C  66 W1-W2     97  98     0 5 0    0.002    0.000   1 0
C    43.550
C    58.852
C  67 W2-X2     98  100    0 2 0    1.675    0.174   53 0
C    42.932   42.868   42.754   42.633   42.610   42.609   42.632   42.635   42.581   42.573   42.614   42.715   42.750   42.771   42.767
42.737   42.707   42.661   42.621   42.570   42.495   42.458   42.464   42.439   42.452   42.443   42.459   42.472   42.473   42.280   42.042
41.936   41.861   41.804   41.754   41.729   41.660   41.545   41.449   41.387   41.305   41.262   41.195   41.126   41.028   40.860   40.787
40.745   40.660   40.604   40.548   40.519   40.484
C    59.722   59.777   59.791   59.870   59.927   60.046   60.090   60.204   60.316   60.400   60.618   60.869   60.994   61.267   61.588
61.821   61.973   62.059   62.088   62.150   62.337   62.497   63.025   63.269   63.596   63.722   63.819   63.894   63.926   64.415   64.811
64.895   64.908   64.974   65.059   65.176   65.467   65.600   65.644   65.694   65.817   66.021   66.132   66.193   66.242   66.488   66.654
66.792   67.197   67.313   67.391   67.472   67.672
C  68 X-X1      24  99     0 1 0    0.951    0.194   3 0
C    42.875   41.554   40.826
C    64.959   67.089   68.065
C  69 X1-X2     99  100    0 5 0    0.002    0.000   1 0
C    40.463
C    68.943
C  70 X2-Y2     100  102   0 2 0    3.205    0.137   90 0
```

C 40.454 40.412 40.387 40.355 40.312 40.242 40.195 40.156 40.141 40.067 39.889 39.764 39.651 39.619 39.522
39.457 39.332 39.259 39.152 39.013 38.861 38.563 38.504 38.293 38.267 38.121 38.083 38.004 37.949 37.891 37.778
37.515 37.440 37.196 37.127 37.031 37.005 36.987 36.991 36.952 36.885 36.824 36.746 36.691 36.518 36.375 36.343
36.298 36.251 36.175 36.084 36.020 35.923 35.887 35.840 35.740 35.692 35.634 35.605 35.539 35.458 35.421 35.230
35.354 35.354 35.004 34.953 34.941 34.940 34.895 34.833 34.720 34.741 34.733 34.686 34.651 34.595 34.538 34.517
34.444 34.383 34.328 34.278 34.235 34.123 34.005 33.985 33.881 33.829 33.806
C 69.082 69.294 69.505 69.666 69.966 70.334 70.957 71.327 71.369 71.774 72.335 72.562 72.824 72.924 73.414
73.638 73.907 74.102 74.268 74.380 74.462 74.575 74.632 74.962 75.039 75.630 75.840 76.037 76.132 76.211 76.363
76.890 76.955 77.046 77.117 77.263 77.344 77.445 77.717 77.952 78.146 78.224 78.456 78.553 78.689 78.920 78.992
79.201 79.344 79.457 79.499 79.560 79.714 79.796 79.872 79.962 80.051 80.231 80.361 80.470 80.547 80.607 81.225
82.111 82.172 83.238 84.078 84.168 84.287 84.662 85.151 85.497 85.875 85.980 86.247 86.350 86.421 86.439 86.521
87.006 87.359 87.530 87.645 87.716 87.901 88.111 88.176 88.391 88.558 88.596
C 71 Y-Y1 25 101 0 1 0 1.269 0.149 5 0
C 35.825 35.367 35.052 34.827 34.236
C 82.202 84.292 86.507 87.958 88.556
C 72 Y1-Y2 101 102 0 5 0 0.002 0.893 1 0
C 33.780
C 88.828
C 73 Z-Z1 26 103 0 1 0 1.018 0.085 7 0
C 38.656 37.425 37.297 37.312 36.847 36.704 36.494
C 36.163 37.802 38.165 38.816 39.116 39.342 39.367
C 74 Z1-Z2 103 104 0 5 0 0.002 0.000 1 0
C 36.142
C 39.044
C 75 Z2-AA2 104 106 0 2 0 0.749 0.103 3 0
C 35.893 35.353 35.017
C 38.898 39.196 39.559
C 76 AA-AA1 27 105 0 2 0 0.526 0.168 5 0
C 33.722 33.595 33.467 33.235 33.093
C 38.809 39.093 39.243 39.693 40.158
C 77 AA1-AA2 105 106 0 5 0 0.002 0.556 1 0
C 33.313
C 42.023
C 78 AA2-AB2 106 108 0 2 0 0.991 0.230 5 0
C 33.396 33.540 33.575 33.795 33.827
C 42.207 42.302 42.554 44.881 45.137
C 79 AC-AC1 28 109 0 1 0 2.013 0.111 10 0
C 43.677 41.736 41.528 40.894 39.237 38.328 38.280 38.205 37.182 36.775
C 41.923 41.040 40.771 40.661 40.882 41.434 42.444 42.760 43.612 44.985
C 80 AC1-AB2 109 108 0 2 0 0.784 0.175 5 0
C 36.325 36.226 35.681 35.071 34.772
C 45.099 45.139 46.819 48.681 48.886
C 81 AB-AB1 29 107 0 1 0 0.544 0.128 1 0
C 35.412
C 48.560
C 82 AB1-AB2 107 108 0 5 0 0.002 0.000 1 0
C 34.225
C 49.299
C 83 AB2-AD2 108 111 0 2 0 0.469 0.002 2 0
C 33.977 33.311
C 49.465 49.658
C 84 AD-AD1 30 110 0 1 0 0.739 0.214 2 0
C 32.829 32.191
C 47.407 48.822
C 85 AD1-AD2 110 111 0 5 0 0.002 0.000 1 0
C 32.187
C 48.832
C 86 AD2-AD3 111 112 0 2 0 0.565 0.078 9 0
C 32.158 32.114 31.907 31.790 31.807 31.802 31.659 31.650 31.506
C 48.851 49.230 50.561 51.321 51.704 51.819 52.292 52.349 52.834
C 87 AD3-AE2 112 114 0 2 0 0.652 0.084 3 0
C 31.432 31.314 31.178
C 53.089 53.530 53.984
C 88 AE-AE1 31 113 0 1 0 1.086 0.126 2 0
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C 51.281 53.947
C 89 AE1-AE2 113 114 0 5 0 0.002 0.445 1 0
C 30.216
C 57.372
C 90 AF-AF1 32 115 0 1 0 0.825 0.271 2 0
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C 51.825 51.932
C 91 AF1-AG2 115 117 0 2 0 0.619 0.076 3 0
C 35.705 35.313 35.065
C 54.433 54.393 54.793
C 92 AG-AG1 33 116 0 1 0 0.526 0.073 1 0
C 35.679
C 54.993
C 93 AG1-AG2 116 117 0 5 0 0.002 0.030 1 0
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C 55.434
C 94 AG2-AD3 117 112 0 2 0 0.748 0.002 1 0
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C 52.794
C 95 AE2-AH2 114 119 0 3 0 0.143 0.071 4 0
C 30.086 29.886 29.798 29.734
C 57.565 57.605 57.645 57.738
C 96 AH-AH1 34 118 0 2 0 1.451 0.136 11 0
C 27.809 27.879 27.718 27.716 27.736 27.775 27.926 27.961 28.477 28.696 29.138
C 49.349 50.047 51.461 51.622 51.832 52.555 53.779 53.794 53.648 55.796 55.699
C 97 AH1-AH2 118 119 0 5 0 0.002 0.062 1 0
C 29.507
C 57.872
C 98 AH2-AI2 119 121 0 2 0 1.107 0.276 25 0

C 29.623 29.606 29.539 29.434 29.351 29.246 28.924 28.878 28.842 28.824 28.693 28.567 28.524 28.429 28.384
28.333 28.202 28.201 28.199 28.162 28.080 28.051 28.050 28.046 27.984
C 57.990 58.044 58.186 58.515 58.939 59.291 60.887 61.163 61.283 61.382 61.786 62.399 62.556 63.036 63.484
63.779 64.217 64.237 64.255 64.361 64.680 64.863 64.869 65.233 65.548
C 99 AI-AI1 35 120 0 1 0 0.740 0.224 1 0
C 29.474
C 63.773
C 100 AI1-AI2 120 121 0 5 0 0.002 0.287 1 0
C 28.072
C 65.726
C 101 AI2-AJ2 121 123 0 2 0 1.767 0.180 55 0
C 28.062 28.025 27.936 27.690 27.662 27.647 27.645 27.680 27.749 27.804 27.806 27.791 27.885 27.764 27.762
27.836 28.127 28.214 28.265 28.297 28.351 28.503 28.582 28.620 28.732 28.843 28.840 28.812 28.704 28.620 28.500
28.377 28.333 28.161 28.097 28.059 28.023 28.109 28.068 27.863 27.810 27.788 27.726 27.632 27.623 27.690 27.698
27.683 27.713 27.740 27.791 27.866 27.939 28.014 28.076
C 66.036 66.168 66.278 66.475 66.513 66.565 66.650 66.765 66.898 67.060 67.247 67.622 68.237 68.569 68.644
68.756 68.991 69.081 69.176 69.281 69.618 70.093 70.280 70.348 70.660 71.225 71.422 71.642 71.902 72.242 72.399
72.599 72.651 72.789 72.911 73.014 73.176 74.105 74.203 74.518 74.693 74.838 75.022 75.215 75.312 75.582 75.804
76.034 76.209 76.272 76.342 76.412 76.454 76.526 76.636
C 102 AJ-AJ1 36 122 0 1 0 1.065 0.181 2 0
C 27.214 27.370
C 72.460 76.157
C 103 AJ1-AJ2 122 123 0 5 0 0.002 0.000 1 0
C 28.099
C 76.759
C 104 AJ2-AM3 123 128 0 3 0 0.032 0.014 1 0
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C 76.884
C 105 AK-AK1 37 124 0 1 0 0.904 0.179 1 0
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C 60.951
C 106 AK1-AM2 124 126 0 2 0 0.774 0.247 1 0
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C 107 AL-AL1 39 125 0 1 0 0.529 0.208 1 0
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C 67.535
C 108 AL1-AM2 125 126 0 5 0 0.002 0.102 1 0
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C 68.027
C 109 AM-AM1 38 127 0 1 0 1.214 0.241 3 0
C 31.360 30.868 30.858
C 61.691 66.848 67.468
C 110 AM1-AM2 127 126 0 5 0 0.002 0.299 1 0
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C 67.947
C 111 AM2-AM3 126 128 0 2 0 1.318 0.230 4 0
C 30.807 30.672 30.564 30.326
C 68.163 69.025 69.547 70.364
C 112 AM3-AN2 128 134 0 2 0 0.852 0.002 25 0
C 28.225 28.222 28.208 28.100 28.154 28.207 28.244 28.274 28.269 28.254 28.210 28.174 28.179 28.207 28.405
28.543 28.643 28.893 29.036 29.082 29.109 29.121 29.120 29.131 29.216
C 77.255 77.437 77.526 77.888 78.086 78.197 78.317 78.504 78.852 78.965 79.157 79.424 79.600 79.725 79.995
80.136 80.179 80.222 80.285 80.359 80.445 80.535 80.725 80.774 80.875
C 113 AN-AN1 40 129 0 1 0 0.852 0.122 1 0
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C 114 AN1-AN2 129 134 0 5 0 0.002 0.000 1 0
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C 81.465
C 115 AO-AO1 41 130 0 1 0 0.963 0.209 2 0
C 38.318 38.485
C 64.965 67.370
C 116 AO1-AP2 130 132 0 1 0 1.470 0.139 18 0
C 38.303 37.942 37.600 37.232 36.838 36.542 36.371 36.141 35.905 35.616 35.248 34.952 34.676 34.164 34.072
33.710 33.645 33.152
C 69.259 69.172 69.281 69.150 69.216 69.511 69.758 70.185 70.524 70.853 71.105 71.411 71.981 71.521 71.554
72.660 72.780 72.671
C 117 AP-AP1 42 131 0 1 0 0.812 0.194 1 0
C 34.126
C 70.350
C 118 AP1-AP2 131 132 0 5 0 0.002 0.440 1 0
C 32.945
C 72.755
C 119 AQ-AQ1 43 133 0 1 0 1.066 0.168 2 0
C 36.256 35.413
C 72.613 72.818
C 120 AQ1-AP2 133 132 0 5 0 0.002 0.267 1 0
C 32.954
C 72.778
C 121 AP2-AN2 132 134 0 2 0 1.464 0.186 28 0
C 32.126 31.727 31.712 31.620 31.603 31.366 31.100 30.911 30.725 30.599 30.556 30.528 30.511 30.424 30.406
30.359 30.143 29.911 29.856 29.829 29.831 29.842 29.917 30.053 30.103 30.093 30.020 29.976
C 74.153 74.922 74.969 75.130 75.183 75.609 75.968 76.183 76.432 76.574 76.642 76.760 76.917 78.398 78.502
78.611 78.740 78.942 79.059 79.474 79.857 80.000 80.245 80.499 80.677 80.863 81.136 81.391
C 122 AR-AR1 44 135 0 1 0 1.007 0.274 2 0
C 31.541 30.701
C 78.498 79.337
C 123 AR1-AN2 135 134 0 5 0 0.002 0.138 1 0
C 29.967
C 81.442
C 124 AS-AS1 45 136 0 1 0 1.095 0.147 1 0
C 45.516
C 70.271

C 125 AS1-AT2 136 138 0 1 0 0.928 0.382 1 0
C 43.103
C 75.186
C 126 AT-AT1 46 137 0 1 0 0.784 0.435 2 0
C 42.065 41.851
C 74.486 76.332
C 127 AT1-AT2 137 138 0 5 0 0.002 0.271 1 0
C 41.801
C 78.110
C 128 AT2-AU2 138 140 0 1 0 0.803 0.280 1 0
C 40.953
C 80.887
C 129 AU-AU1 47 139 0 1 0 0.966 0.328 1 0
C 40.269
C 79.861
C 130 AU1-AU2 139 140 0 5 0 0.002 0.184 1 0
C 40.101
C 83.541
C 131 AU2-AV2 140 142 0 2 0 0.643 0.192 4 0
C 39.959 39.653 39.829 40.326
C 83.944 84.932 85.049 86.670
C 132 AV-AV1 48 141 0 1 0 0.895 0.272 1 0
C 39.787
C 84.589
C 133 AV1-AV2 141 142 0 5 0 0.002 0.000 1 0
C 40.496
C 87.794
C 134 AV2-AW2 142 144 0 2 0 0.428 0.002 3 0
C 40.501 40.398 40.445
C 88.147 89.225 90.852
C 135 AW-AW1 49 143 0 1 0 1.047 0.224 1 0
C 38.978
C 87.955
C 136 AW1-AW2 143 144 0 5 0 0.002 0.033 1 0
C 40.508
C 91.042
C 137 AW2-BB2 144 153 0 2 0 0.339 0.022 6 0
C 40.640 40.743 40.796 41.113 41.189 41.369
C 91.128 91.367 91.561 92.050 92.205 92.883
C 138 AX-AX1 50 145 0 1 0 0.645 0.174 1 0
C 48.391
C 72.968
C 139 AX1-AY2 145 147 0 1 0 1.204 0.303 4 0
C 46.855 45.749 45.709 45.882
C 75.960 79.692 81.380 83.068
C 140 AY-AY1 51 146 0 1 0 1.038 0.276 2 0
C 48.093 47.493
C 79.850 81.383
C 141 AY1-AY2 146 147 0 5 0 0.002 0.334 1 0
C 45.914
C 84.199
C 142 AY2-AZ2 147 149 0 2 0 0.226 0.139 1 0
C 45.835
C 85.515
C 143 AZ-AZ1 52 148 0 1 0 1.217 0.213 2 0
C 48.253 47.573
C 83.426 84.648
C 144 AZ1-AZ2 148 149 0 5 0 0.002 0.124 1 0
C 45.810
C 85.911
C 145 AZ2-BA2 149 151 0 2 0 0.538 0.215 12 0
C 45.755 45.747 45.697 45.627 45.589 45.529 45.522 45.463 45.434 45.326 45.300 44.822
C 86.152 86.282 86.712 87.176 87.604 87.973 88.061 88.348 88.405 88.560 88.574 89.215
C 146 BA-BA1 53 150 0 1 0 0.721 0.138 1 0
C 44.561
C 86.576
C 147 BA1-BA2 150 151 0 5 0 0.002 0.269 1 0
C 44.703
C 89.323
C 148 BA2-BB2 151 153 0 2 0 0.880 0.184 19 0
C 44.579 44.247 43.825 43.457 43.248 43.102 43.060 43.007 42.970 42.948 42.937 42.894 42.600 42.259 42.043
41.994 41.768 41.679 41.546
C 89.423 89.527 89.891 90.154 90.323 90.545 90.630 90.764 90.896 91.181 91.234 91.296 91.519 91.872 92.137
92.183 92.508 92.600 92.812
C 149 BB-BB1 54 152 0 1 0 0.596 0.116 1 0
C 42.316
C 90.975
C 150 BB1-BB2 152 153 0 5 0 0.002 0.049 1 0
C 41.526
C 92.829
C 151 BB2-BB3 153 154 0 2 0 0.186 0.065 4 0
C 41.470 41.397 41.280 41.224
C 93.243 93.544 93.802 94.010
C 152 AN2-OUTLET 134 155 0 5 0 0.000 0.000 1 0
C 29.863
C 88.407
C 153 Y2-OUTLET 102 155 0 5 0 0.000 0.000 1 0
C 31.740
C 92.089
C 154 BB3-OUTLET 154 155 0 5 0 0.000 0.000 1 0
C 35.484
C 94.793
C
C #STORAGES

```
C   0
C
C #INFLOW/OUTFLOW
C   0
C
C END RORB_GE
C
C File created using MiRORB version 1.2
C Original CATG file created on 27/05/2014 at 15:41:32
0
1, 1, 1.402, -99          ,Reach 1 node 1     Sub-area A, Reach A-A1 - Generate rainfall excess h'graph and route downstream
5, 1, .095, -99           ,Reach 2            Reach A1-B2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 1, .960, -99           ,Reach 3 node 2     Sub-area B, Reach B-B1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
5, 1, .224, -99           ,Reach 5            Reach B2-B3 - Route running h'graph downstream
5, 1, .170, -99           ,Reach 8            Reach B3-C2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 1, 1.166, -99          ,Reach 6 node 3     Sub-area C, Reach C-C1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
7.2               ,             PRINT
KennedyCkEUpper_C2
5, 1, .332, -99           ,Reach 9            Reach C2-D2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 1, .762, -99           ,Reach 10 node 4    Sub-area D, Reach D-D1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
5, 1, .225, -99           ,Reach 12           Reach D2-D3 - Route running h'graph downstream
5, 2, .942, .318, -99     ,Reach 13           Reach D3-E2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 1, 1.168, -99          ,Reach 14 node 5    Sub-area E, Reach E-E1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
5, 2, .850, .002, -99     ,Reach 16           Reach E2-F2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 1, 1.580, -99          ,Reach 17 node 6    Sub-area F, Reach F-F1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
5, 2, .202, .125, -99     ,Reach 30           Reach F2-J3 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 2, .526, .108, -99     ,Reach 31 node 11   Sub-area K, Reach K-K1 - Generate rainfall excess h'graph and route downstream
5, 2, 1.290, .423, -99    ,Reach 32           Reach K1-L2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 1, .621, -99           ,Reach 33 node 12   Sub-area L, Reach L-L1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
5, 2, .756, .192, -99     ,Reach 35           Reach L2-M2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 1, .793, -99           ,Reach 36 node 13   Sub-area M, Reach M-M1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
7.2               ,             PRINT
KennedyCkWUpper_M2
5, 2, .796, .177, -99     ,Reach 38           Reach M2-N2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 2, .453, .222, -99     ,Reach 39 node 14   Sub-area N, Reach N-N1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
5, 2, .892, .144, -99     ,Reach 41           Reach N2-O2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 1, 1.115, -99          ,Reach 42 node 15   Sub-area O, Reach O-O1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
5, 2, .270, .002, -99     ,Reach 44           Reach O2-J2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 1, .660, -99           ,Reach 19 node 7    Sub-area G, Reach G-G1 - Generate rainfall excess h'graph and route downstream
5, 1, 1.009, -99          ,Reach 20           Reach G1-H2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 1, .679, -99           ,Reach 21 node 8    Sub-area H, Reach H-H1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
5, 1, 1.501, -99          ,Reach 23           Reach H2-I2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 2, .723, .334, -99     ,Reach 24 node 9    Sub-area I, Reach I-I1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
7.2               ,             PRINT
KennedyCkMUpper_I2
5, 2, 2.278, .236, -99    ,Reach 26           Reach I2-J2 - Route running h'graph downstream
4                 ,             Add running h'graph to last stored h'graph
3                 ,             Store running hydrograph
1, 1, 1.238, -99          ,Reach 27 node 10   Sub-area J, Reach J-J1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
5, 2, .017, .078, -99     ,Reach 29           Reach J2-J3 - Route running h'graph downstream
4                 ,             Add running h'graph to last stored h'graph
7.2               ,             PRINT
KennedyCkHilbrickRd_J3
5, 2, 1.230, .263, -99    ,Reach 45           Reach J3-J4 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 1, 2.202, -99          ,Reach 46 node 17   Sub-area Q, Reach Q-Q1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
5, 2, .104, .404, -99     ,Reach 48           Reach J4-P2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 1, .949, -99           ,Reach 49 node 16   Sub-area P, Reach P-P1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
5, 3, .679, .151, -99     ,Reach 51           Reach P2-R2 - Route running h'graph downstream
3                 ,             Store running hydrograph
1, 1, 1.493, -99          ,Reach 52 node 18   Sub-area R, Reach R-R1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
3                 ,             Store running hydrograph
1, 1, 1.312, -99          ,Reach 54 node 19   Sub-area S, Reach S-S1 - Generate rainfall excess h'graph and route downstream
4                 ,             Add running h'graph to last stored h'graph
3                 ,             Store running hydrograph
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1, 1, 1.643, -99        ,Reach 56 node 20    Sub-area T, Reach T-T1 - Generate rainfall excess h'graph and route downstream
4                 ,     Add running h'graph to last stored h'graph
7                 ,     PRINT
R2
5, 2, .815, .002, -99   ,Reach 60            Reach R2-U2 - Route running h'graph downstream
3                 ,     Store running hydrograph
1, 1, 1.082, -99        ,Reach 58 node 21    Sub-area U, Reach U-U1 - Generate rainfall excess h'graph and route downstream
7                 ,     PRINT
U1
4                 ,     Add running h'graph to last stored h'graph
5, 2, .825, .083, -99   ,Reach 61            Reach U2-V2 - Route running h'graph downstream
3                 ,     Store running hydrograph
1, 1, 1.078, -99        ,Reach 62 node 22    Sub-area V, Reach V-V1 - Generate rainfall excess h'graph and route downstream
7                 ,     PRINT
V1
4                 ,     Add running h'graph to last stored h'graph
5, 2, 1.040, .202, -99  ,Reach 64            Reach V2-W2 - Route running h'graph downstream
3                 ,     Store running hydrograph
1, 1, .504, -99         ,Reach 65 node 23    Sub-area W, Reach W-W1 - Generate rainfall excess h'graph and route downstream
7                 ,     PRINT
W1
4                 ,     Add running h'graph to last stored h'graph
7.2               ,     PRINT
KennedyCkRailwayLine_W2
5, 2, 1.675, .174, -99  ,Reach 67            Reach W2-X2 - Route running h'graph downstream
3                 ,     Store running hydrograph
1, 1, .951, -99         ,Reach 68 node 24    Sub-area X, Reach X-X1 - Generate rainfall excess h'graph and route downstream
7                 ,     PRINT
X1
4                 ,     Add running h'graph to last stored h'graph
5, 2, 3.205, .137, -99  ,Reach 70            Reach X2-Y2 - Route running h'graph downstream
3                 ,     Store running hydrograph
1, 1, 1.269, -99        ,Reach 71 node 25    Sub-area Y, Reach Y-Y1 - Generate rainfall excess h'graph and route downstream
7                 ,     PRINT
Y1
4                 ,     Add running h'graph to last stored h'graph
7.2               ,     PRINT
KennedyCkOutlfall_Y2
3                 ,     Store running hydrograph
1, 1, 1.018, -99        ,Reach 73 node 26    Sub-area Z, Reach Z-Z1 - Generate rainfall excess h'graph and route downstream
7                 ,     PRINT
Z2
5, 2, .749, .103, -99   ,Reach 75            Reach Z2-AA2 - Route running h'graph downstream
3                 ,     Store running hydrograph
1, 2, .526, .168, -99   ,Reach 76 node 27    Sub-area AA, Reach AA-AA1 - Generate rainfall excess h'graph and route downstream
7                 ,     PRINT
AA1
4                 ,     Add running h'graph to last stored h'graph
5, 2, .991, .230, -99   ,Reach 78            Reach AA2-AB2 - Route running h'graph downstream
3                 ,     Store running hydrograph
1, 1, 2.013, -99        ,Reach 79 node 28    Sub-area AC, Reach AC-AC1 - Generate rainfall excess h'graph and route downstream
7                 ,     PRINT
AC1
5, 2, .784, .175, -99   ,Reach 80            Reach AC1-AB2 - Route running h'graph downstream
4                 ,     Add running h'graph to last stored h'graph
3                 ,     Store running hydrograph
1, 1, .544, -99         ,Reach 81 node 29    Sub-area AB, Reach AB-AB1 - Generate rainfall excess h'graph and route downstream
7                 ,     PRINT
AB1
4                 ,     Add running h'graph to last stored h'graph
7.2               ,     PRINT
BenellaRailwayLine_AB2
5, 2, .469, .002, -99   ,Reach 83            Reach AB2-AD2 - Route running h'graph downstream
3                 ,     Store running hydrograph
1, 1, .739, -99         ,Reach 84 node 30    Sub-area AD, Reach AD-AD1 - Generate rainfall excess h'graph and route downstream
4                 ,     Add running h'graph to last stored h'graph
5, 2, .565, .078, -99   ,Reach 86            Reach AD2-AD3 - Route running h'graph downstream
3                 ,     Store running hydrograph
1, 1, .825, -99         ,Reach 90 node 32    Sub-area AF, Reach AF-AF1 - Generate rainfall excess h'graph and route downstream
7                 ,     PRINT
AF1
5, 2, .619, .076, -99   ,Reach 91            Reach AF1-AG2 - Route running h'graph downstream
3                 ,     Store running hydrograph
1, 1, .526, -99         ,Reach 92 node 33    Sub-area AG, Reach AG-AG1 - Generate rainfall excess h'graph and route downstream
7                 ,     PRINT
AG1
4                 ,     Add running h'graph to last stored h'graph
5, 2, .748, .002, -99   ,Reach 94            Reach AG2-AD3 - Route running h'graph downstream
4                 ,     Add running h'graph to last stored h'graph
5, 2, .652, .084, -99   ,Reach 87            Reach AD3-AE2 - Route running h'graph downstream
3                 ,     Store running hydrograph
1, 1, 1.086, -99        ,Reach 88 node 31    Sub-area AE, Reach AE-AE1 - Generate rainfall excess h'graph and route downstream
4                 ,     Add running h'graph to last stored h'graph
5, 3, .143, .071, -99   ,Reach 95            Reach AE2-AH2 - Route running h'graph downstream
3                 ,     Store running hydrograph
1, 2, 1.451, .136, -99  ,Reach 96 node 34    Sub-area AH, Reach AH-AH1 - Generate rainfall excess h'graph and route downstream
4                 ,     Add running h'graph to last stored h'graph
7.2               ,     PRINT
BenellaRacecourseRd_AH2
5, 2, 1.107, .276, -99  ,Reach 98            Reach AH2-AI2 - Route running h'graph downstream
3                 ,     Store running hydrograph
1, 1, .740, -99         ,Reach 99 node 35    Sub-area AI, Reach AI-AI1 - Generate rainfall excess h'graph and route downstream
4                 ,     Add running h'graph to last stored h'graph
5, 2, 1.767, .180, -99  ,Reach 101           Reach AI2-AJ2 - Route running h'graph downstream
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3	,	Store running hydrograph
1, 1, 1.065, -99	,Reach 102 node 36	Sub-area AJ, Reach AJ-AJ1 - Generate rainfall excess h'graph and route downstream
7	,	PRINT
AJ1		
4	,	Add running h'graph to last stored h'graph
5, 3, .032, .014, -99	,Reach 104	Reach AJ2-AM3 - Route running h'graph downstream
3	,	Store running hydrograph
1, 1, .904, -99	,Reach 105 node 37	Sub-area AK, Reach AK-AK1 - Generate rainfall excess h'graph and route downstream
7	,	PRINT
AK1		
5, 2, .774, .247, -99	,Reach 106	Reach AK1-AM2 - Route running h'graph downstream
3	,	Store running hydrograph
1, 1, 1.214, -99	,Reach 109 node 38	Sub-area AM, Reach AM-AM1 - Generate rainfall excess h'graph and route downstream
7	,	PRINT
AM1		
4	,	Add running h'graph to last stored h'graph
3	,	Store running hydrograph
1, 1, .529, -99	,Reach 107 node 39	Sub-area AL, Reach AL-AL1 - Generate rainfall excess h'graph and route downstream
7	,	PRINT
AL1		
4	,	Add running h'graph to last stored h'graph
5, 2, 1.318, .230, -99	,Reach 111	Reach AM2-AM3 - Route running h'graph downstream
4	,	Add running h'graph to last stored h'graph
7.2	,	PRINT
BenellaNorthRd_AM3		
5, 2, .852, .002, -99	,Reach 112	Reach AM3-AN2 - Route running h'graph downstream
3	,	Store running hydrograph
1, 1, .963, -99	,Reach 115 node 41	Sub-area AO, Reach AO-AO1 - Generate rainfall excess h'graph and route downstream
7	,	PRINT
AO1		
5, 1, 1.470, -99	,Reach 116	Reach AO1-AP2 - Route running h'graph downstream
3	,	Store running hydrograph
1, 1, .812, -99	,Reach 117 node 42	Sub-area AP, Reach AP-AP1 - Generate rainfall excess h'graph and route downstream
7	,	PRINT
AP1		
4	,	Add running h'graph to last stored h'graph
3	,	Store running hydrograph
1, 1, 1.066, -99	,Reach 119 node 43	Sub-area AQ, Reach AQ-AQ1 - Generate rainfall excess h'graph and route downstream
7	,	PRINT
AQ1		
4	,	Add running h'graph to last stored h'graph
5, 2, 1.464, .186, -99	,Reach 121	Reach AP2-AN2 - Route running h'graph downstream
4	,	Add running h'graph to last stored h'graph
3	,	Store running hydrograph
1, 1, .852, -99	,Reach 113 node 40	Sub-area AN, Reach AN-AN1 - Generate rainfall excess h'graph and route downstream
7	,	PRINT
AN1		
4	,	Add running h'graph to last stored h'graph
3	,	Store running hydrograph
1, 1, 1.007, -99	,Reach 122 node 44	Sub-area AR, Reach AR-AR1 - Generate rainfall excess h'graph and route downstream
7	,	PRINT
AR1		
4	,	Add running h'graph to last stored h'graph
7.2	,	PRINT
BenellaOutlet_AN2		
4	,	Add running h'graph to last stored h'graph
3	,	Store running hydrograph
1, 1, 1.095, -99	,Reach 124 node 45	Sub-area AS, Reach AS-AS1 - Generate rainfall excess h'graph and route downstream
5, 1, .928, -99	,Reach 125	Reach AS1-AT2 - Route running h'graph downstream
3	,	Store running hydrograph
1, 1, .784, -99	,Reach 126 node 46	Sub-area AT, Reach AT-AT1 - Generate rainfall excess h'graph and route downstream
4	,	Add running h'graph to last stored h'graph
7	,	PRINT
AT2		
5, 1, .803, -99	,Reach 128	Reach AT2-AU2 - Route running h'graph downstream
3	,	Store running hydrograph
1, 1, .966, -99	,Reach 129 node 47	Sub-area AU, Reach AU-AU1 - Generate rainfall excess h'graph and route downstream
7	,	PRINT
AU1		
4	,	Add running h'graph to last stored h'graph
7.2	,	PRINT
EastTribLinkRdWest_AU2		
5, 2, .643, .192, -99	,Reach 131	Reach AU2-AV2 - Route running h'graph downstream
3	,	Store running hydrograph
1, 1, .895, -99	,Reach 132 node 48	Sub-area AV, Reach AV-AV1 - Generate rainfall excess h'graph and route downstream
7	,	PRINT
AV1		
4	,	Add running h'graph to last stored h'graph
5, 2, .428, .002, -99	,Reach 134	Reach AV2-AW2 - Route running h'graph downstream
3	,	Store running hydrograph
1, 1, 1.047, -99	,Reach 135 node 49	Sub-area AW, Reach AW-AW1 - Generate rainfall excess h'graph and route downstream
7	,	PRINT
AW1		
4	,	Add running h'graph to last stored h'graph
5, 2, .339, .022, -99	,Reach 137	Reach AW2-BB2 - Route running h'graph downstream
3	,	Store running hydrograph
1, 1, .645, -99	,Reach 138 node 50	Sub-area AX, Reach AX-AX1 - Generate rainfall excess h'graph and route downstream
5, 1, 1.204, -99	,Reach 139	Reach AX1-AY2 - Route running h'graph downstream
3	,	Store running hydrograph
1, 1, 1.038, -99	,Reach 140 node 51	Sub-area AY, Reach AY-AY1 - Generate rainfall excess h'graph and route downstream
4	,	Add running h'graph to last stored h'graph
5, 2, .226, .139, -99	,Reach 142	Reach AY2-AZ2 - Route running h'graph downstream
3	,	Store running hydrograph
1, 1, 1.217, -99	,Reach 143 node 52	Sub-area AZ, Reach AZ-AZ1 - Generate rainfall excess h'graph and route downstream

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4                            ,                    Add running h'graph to last stored h'graph
7.2                          ,                    PRINT
EastTribLinkRdEast_AZ2
5, 2, .538, .215, -99             ,Reach 145          Reach AZ2-BA2 - Route running h'graph downstream
3                            ,                    Store running hydrograph
1, 1, .721, -99                 ,Reach 146 node 53       Sub-area BA, Reach BA-BA1 - Generate rainfall excess h'graph and route downstream
4                            ,                    Add running h'graph to last stored h'graph
5, 2, .880, .184, -99             ,Reach 148          Reach BA2-BB2 - Route running h'graph downstream
4                            ,                    Add running h'graph to last stored h'graph
3                            ,                    Store running hydrograph
1, 1, .596, -99                 ,Reach 149 node 54       Sub-area BB, Reach BB-BB1 - Generate rainfall excess h'graph and route downstream
4                            ,                    Add running h'graph to last stored h'graph
5, 2, .186, .065, -99             ,Reach 151          Reach BB2-BB3 - Route running h'graph downstream
7.2                          ,                    PRINT
EastTribOutlet_BB3
4                            ,                    Add running h'graph to last stored h'graph
0
C Sub-area areas in km2
  1.179,  0.699,  0.955,  0.683,  1.028,
  1.268,  0.460,  1.057,  1.046,  0.574,
  1.116,  0.782,  0.694,  0.655,  0.804,
  1.158,  0.988,  1.247,  0.910,  1.061,
  1.195,  1.063,  0.961,  1.189,  1.015,
  1.358,  0.814,  1.577,  0.762,  0.852,
  0.746,  0.514,  1.114,  1.175,  0.799,
  1.278,  0.670,  0.547,  0.711,  1.261,
  0.737,  0.949,  0.819,  0.835,  0.836,
  0.919,  0.883,  0.701,  1.082,  0.643,
  0.977,  0.604,  0.613,  0.881,
 -99
C Impervious Fraction Data
 1 ,
  0.050,  0.050,  0.050,  0.048,  0.050,
  0.050,  0.050,  0.050,  0.050,  0.050,
  0.050,  0.050,  0.050,  0.050,  0.050,
  0.050,  0.050,  0.129,  0.075,  0.099,
  0.055,  0.054,  0.114,  0.050,  0.050,
  0.100,  0.424,  0.245,  0.434,  0.538,
  0.150,  0.150,  0.150,  0.200,  0.145,
  0.192,  0.207,  0.172,  0.231,  0.095,
  0.051,  0.193,  0.596,  0.599,  0.050,
  0.050,  0.050,  0.050,  0.050,  0.076,
  0.052,  0.050,  0.064,  0.078,
 -99
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