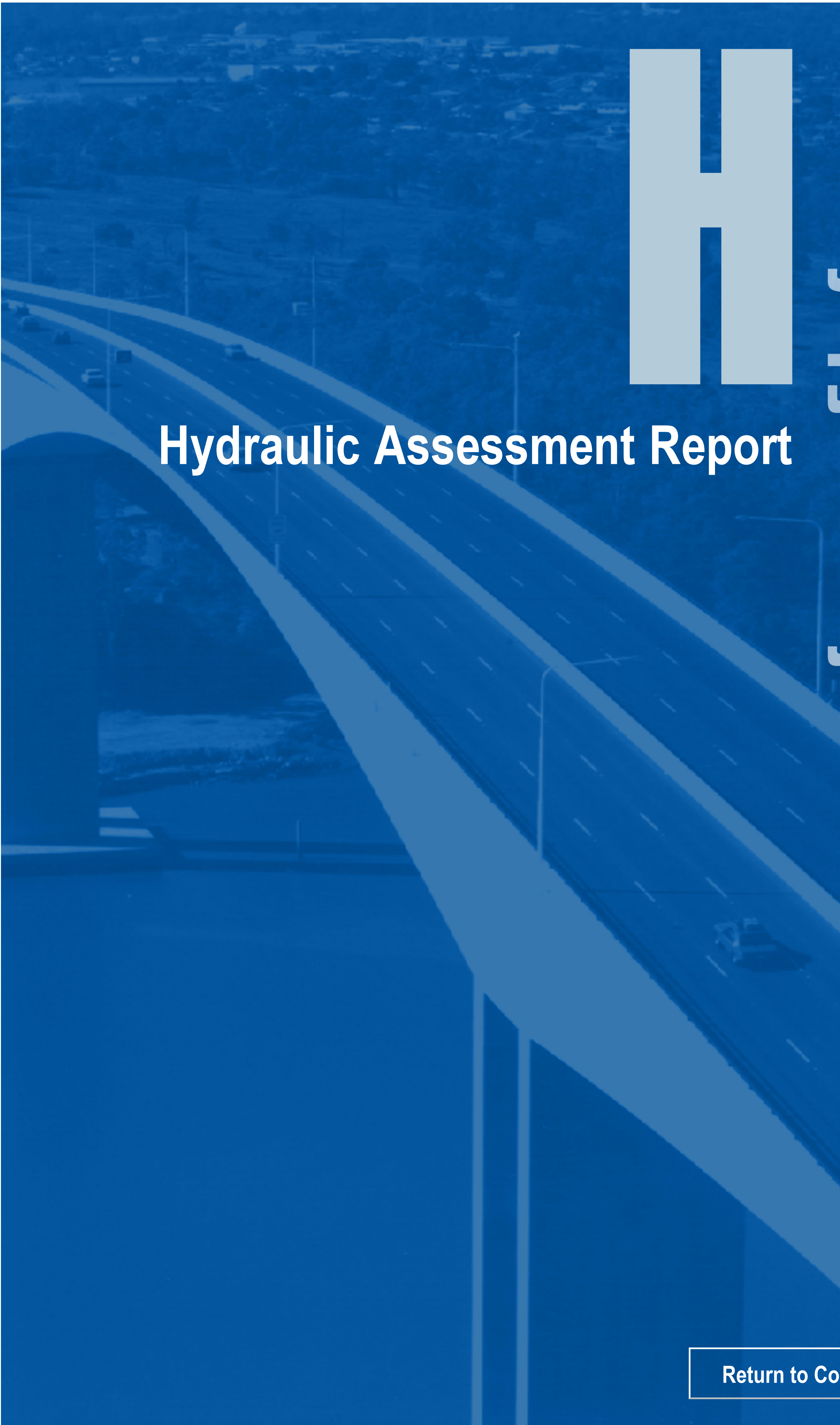

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Hydraulic Assessment Report

Gateway Upgrade Project

Return to Contents Page

Connell Wagner Pty Ltd
ABN 54 005 139 873
433 Boundary Street
Spring Hill
Queensland 4004 Australia

Telephone: +61 7 3246 1000
Facsimile: +61 7 3246 1001
Email: cwbne@conwag.com
www.conwag.com

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Table of Contents

Section	Page
List of Figures	**ii**
List of Abbreviations	**iii**
1. Introduction	**1**
2. Available Data	**2**
2.1 Existing Hydraulic Models	2
2.2 Topography and Survey Data	3
2.3 Flood Regulation Line Details	3
2.4 Design Drawings	3
2.5 Site Inspection	4
3. Review of Proposed GUP Works	**5**
3.1 Mt Gravatt-Capalaba Road to Cleveland Branch Rail Line	5
3.2 Cleveland Branch Rail Line to Pinkenba Rail Line	5
3.3 Pinkenba Rail Line to Nudgee Road	5
4. Hydraulic Analysis	**7**
4.1 General	7
4.2 Modelling Approach	7
4.3 Bulimba Creek Hydraulic Modelling	8
4.4 Kedron Brook Floodway Hydraulic Modelling	10
5. Bulimba Creek Modelling Results	**13**
5.1 Base Case Flood Conditions	13
5.2 Impact of the Gateway Upgrade Project Works	13
5.3 Mitigation Options Assessment	14
5.4 Summary of Mitigation Options and Outcomes	15
6. Kedron Brook Floodway Modelling Results	**16**
6.1 Base Case Flood Conditions	16
6.2 Impact of the Gateway Upgrade Project Works	16
6.3 Mitigation Options Assessment	16
6.4 Summary of Outcomes	18
7. Bulimba Creek MEL Culverts	**20**
7.1 General	20
7.2 Characteristics of the MEL Culverts	20
7.3 Hydraulic Losses through the MEL Culverts	20
7.4 Bulimba Creek Overflow Culvert (Minnippi Bypass – Ch 13100) Upgrade	20
7.5 Bulimba Creek Overbank Culvert Upgrade (Ch 14260)	21
8. Conclusions	**22**
9. References	**23**
Figures	

List of Figures

Figure 1 Bulimba Creek and Surrounding Environment

Figure 2 Kedron Brook and Surrounding Environment

Figure 3 Bulimba Creek Model Extent

Figure 4 Bulimba Creek – MIKE 21 Model Calibration Results

Figure 5 Kedron Brook Model Extent

Figure 6 Kedron Brook – MIKE 21 Model Calibration Results

Figure 7a Bulimba Creek – Base Case 100 year ARI Peak Water Levels

Figure 7b Bulimba Creek – Alternate Base Case 100 year ARI Peak Water Levels

Figure 8a Bulimba Creek – Base Case 100 year ARI Peak Depths

Figure 8b Bulimba Creek – Alternate Base Case 100 year ARI Peak Depths

Figure 9a Bulimba Creek – Impact of GUP Works (Developed Case vs Base Case)

Figure 9b Bulimba Creek – Impact of GUP Works (Developed Case vs Alternate Base Case)

Figure 10 Bulimba Creek – Mitigation Option 1 Results

Figure 11 Bulimba Creek – Mitigation Option 2 Results

Figure 12 Kedron Brook – Base Case 100 year ARI Peak Water Levels

Figure 13 Kedron Brook – Base Case 100 year ARI Peak Depths

Figure 14 Kedron Brook – Impact of GUP Works (Developed Case)

Figure 15 Kedron Brook – Mitigation Option 1 Results

Figure 16 Kedron Brook – Mitigation Option 2 Results

Figure 17 Kedron Brook – Mitigation Option 3 Results

Figure 18 Kedron Brook – Mitigation Option 4 Results

Figure 19 Kedron Brook – Mitigation Option 5 Results

Figure 20 Kedron Brook – Mitigation Option 6 Results

Figure 21 Kedron Brook – Mitigation Option 7 Results

Figure 22 Kedron Brook – Mitigation Option 8 Results

Figure 23 Kedron Brook – Mitigation Option 9 Results

Figure 24 Kedron Brook – Mitigation Option 10 Results

Figure 25 Kedron Brook – Mitigation Option 11 Results

List of Abbreviations

ALS	Aerial Laser Survey
ARI	Average Recurrence Interval
BCC	Brisbane City Council
DTM	Digital Terrain Map
FRL	Flood Regulation Line
GUP	Gateway Upgrade Project
MEL	Minimum Energy Loss
WSL	Water Surface Level

1. Introduction

The Gateway Upgrade Project (GUP) has the potential to impact upon the hydraulic regime of a number of waterways located along the proposed alignment. Extending from Mount Gravatt-Capalaba Road in the south, to Nudgee Road in the north, this investigation examines in detail the watercourses crossed and the potential impacts that may result from the GUP works.

There are two major creek crossings in particular that have been examined in detail, being Bulimba Creek and Kedron Brook Floodway. Both of these systems are highly sensitive to flooding impacts with existing properties already at risk from inundation under large flood events. This hydraulic impact assessment has been undertaken to achieve the following objectives:

- Provision of Base Case (ie Existing Case) hydraulic information including flood levels, flows and velocities for the 100 year ARI design event;
- Determination of impacts on the flood regime of adjacent waterways due to introduction of the works (eg bridge crossings, culverts and embankments) associated with the GUP; and
- Development and evaluation of mitigation options to minimise the impact of the proposed works.
- Recommendation of suitable mitigation options for both Bulimba Creek and Kedron Brook Floodway.

In order to address the above objectives, detailed 2-dimensional MIKE 21 hydraulic models have been set up to represent both the Bulimba Creek and Kedron Brook Floodway systems. These models have been based on the recent Aerial Laser Survey (ALS) covering the floodplains of both waterways. Calibration of the MIKE 21 hydraulic models has been carried out against flood levels available for the 100 year ARI design event from the Planning Study MIKE 11 model of Bulimba Creek and HEC-RAS model of Kedron Brook Floodway. For this investigation the 2-dimensional MIKE 21 modelling was adopted to enable more accurate modelling of the highly complex and meandering Bulimba Creek system and the skewed bridge crossing over Kedron Brook Floodway.

In addition to the main creek crossings, impacts on a number of minor crossings are examined and evaluated.

This report documents the investigative work undertaken, presents details of the existing environment, outlines the potential impacts of the GUP works on the adjacent waterways, and evaluates and recommends mitigation options to address these impacts.

2. Available Data

A wide range of data was available for use on the GUP, details of the data used are provided below.

2.1 Existing Hydraulic Models

One-dimensional hydraulic models of both the Bulimba Creek and Kedron Brook Floodway systems were developed during the initial Planning Study and used to assess the impacts of the Gateway Upgrade Project. Connell Wagner obtained these models for use with the current study:

- To provide appropriate inflow and level boundary conditions for the more detailed two-dimensional models developed for the current study;
- To provide peak water levels for comparison with the current two-dimensional models; and
- To confirm that the results of the two-dimensional modelling were of the correct order of magnitude.

The available models are discussed in detail below.

2.1.1 Bulimba Creek

GHD developed a hydraulic model of Bulimba Creek using the MIKE 11 software package. The model was based upon a copy of the current MIKE 11 model for Bulimba Creek provided by Brisbane City Council, which was in turn based upon hydraulic models prepared for BCC by Connell Wagner (1992) and Sinclair Knight Merz (1999) during previous investigations of Bulimba Creek. Connell Wagner's model was a RUBICON hydraulic model and this was converted to MIKE 11 by City Design/SKM.

The MIKE 11 model extends from upstream of Beenleigh Road in Runcorn to approximately 3km downstream of the bridge. The model includes several smaller tributaries and overbank bypasses, including the Minnippi Branch, a breakout branch crossing the Gateway Motorway in Tingalpa and running in a northerly direction across Wynnum Road.

The MIKE 11 modelling was conducted assuming 'ultimate' development catchment conditions, as described in the Bulimba Creek Draft Water Quantity Assessment (Brisbane City Council, 2001), which assume:

- Ultimate development flowrates resulting from planned ultimate urbanisation and development within the catchment;
- Ultimate development along Bulimba Creek up to the Brisbane City Council Flood Regulation Lines; and
- Consideration and incorporation of revegetation strategies along the waterway corridor.

The 100 year ARI flood event was adopted as the design event for all hydraulic modelling tasks with a fixed tailwater level adopted.

2.1.2 Kedron Brook Floodway

Assessment of the impacts of the Gateway Upgrade Project during the Planning Study was undertaken by GHD using a one-dimensional steady-state HEC-RAS model. The model includes Kedron Brook Floodway from just upstream of Sandgate Road to the mouth of Kedron Brook Floodway, including Schulz Canal, Cannery Drain and Pound Drain. Input parameters for this model were taken from the Kedron Brook Flood Study which included the development of a RUBICON hydraulic model of the creek system. This study was prepared for Brisbane City Council by Connell Wagner in 1996.

Flow and level results from the Kedron Brook Flood Study (KBFS) model were used as boundary conditions in the current modelling work.

2.2 Topography and Survey Data

The hydraulic models developed and used for this study have been based upon Aerial Laser Survey (ALS) data provided by the Department of Main Roads. The ALS data coverage of Bulimba Creek extends from upstream of the Minnippi Parklands to Gross Avenue, Hemmant, and covers an area of approximately 900ha. The ALS data of the Kedron Brook area covers an area of 1,360ha, and extends from Melton Road to a short distance downstream of the Nudgee Golf Course. The ALS data extents for Bulimba Creek and Kedron Brook Floodway are presented in Figures 3 and 4 respectively.

In inundated areas, such as creeks or lakes, the aerial laser survey method returns levels from the water surface rather than the creek or lake bed level. The cross-sectional data from the one-dimensional hydraulic models used in the Planning Study were used to augment the ALS survey data to provide information below the water surface level (WSL) for the areas that were under water during the aerial survey, including:

- Bulimba Creek main channel and the Minnippi bypass channel; and
- Kedron Brook Floodway main channel and Cannery, Pound and Battery Drains.

The ALS data (above WSL) and cross-section data (below WSL) were incorporated into a combined digital terrain model (DTM) for each investigation area using 12D. These DTMs were used to generate the topography used for the two-dimensional hydraulic modelling. Dredging has occurred over time on Kedron Brook Floodway and for the purposes of this investigation the survey sections used in the Kedron Brook Floodway hydraulic model were adopted to represent the bed levels. This approach was discussed with BCC officers and agreed upon, as the data is best information available and no further survey data has been obtained since completion of the original study.

2.3 Flood Regulation Line Details

The hydraulic modelling for the current study was conducted assuming ultimate development along Bulimba Creek and Kedron Brook Floodway up to the limits set by the Brisbane City Council Flood Regulation Lines (FRL). FRL details were obtained from Brisbane City Council's BIMAP system.

An AutoCAD version of the FRL details for Kedron Brook Floodway was supplied from the Planning Study work. This version was reviewed, and a discrepancy at the pinch point downstream of Cannery Drain on the northern bank was identified. The AutoCAD file was adjusted to reflect the BIMAP version.

2.4 Design Drawings

Original design drawings of the existing structures, particularly those in the Bulimba Creek area, were obtained from MR and from the Planning Study for the proposed works. Specific details extracted from these drawings for the modelling include:

- Location, alignment and dimensions of the existing and proposed Gateway Motorway bridge crossings across Bulimba Creek;
- Details of the proposed modifications required for the existing Bulimba Creek bridge piers;
- Layout of the minimum energy loss (MEL) culverts on Bulimba Creek;
- Details of proposed widening works at the MEL culverts; and
- Location, alignment and dimensions of the proposed bridge crossing of Kedron Brook Floodway and associated embankments.

2.5 Site Inspection

Several site visits were carried out within the Bulimba Creek and Kedron Brook Floodway model areas, for the purpose of:

- Assessing primary and secondary flow paths, and comparing them to those in the model;
- Assessing the existing environmental conditions (eg roughness);
- Identifying areas suitable for flood mitigation options;
- Identifying topographical discrepancies with the ALS data received;
- Identifying any irregularities within the catchment, eg areas of illegally dumped material; and
- Review of location of potential impacted properties.

From the site inspections and review of the aerial photography an area of illegal fill was identified both upstream and downstream of the existing Gateway Bridge at the Bulimba Creek crossing. This material was found to have significant affects on flood levels in this area.

3. Review of Proposed GUP Works

3.1 Mt Gravatt-Capalaba Road to Cleveland Branch Rail Line

In this portion of the works, the GUP alignment closely follows that of the existing Gateway Motorway and as such does not create any new surface water crossing locations. Instead augmentation of a number of existing crossings is required, including the Bulimba Creek Bridge crossing, two minimum energy culverts and other minor culvert.

The main waterway in this area is Bulimba Creek, which is subject to tidal flows and ultimately drains into the Brisbane River. A large portion of the Bulimba Creek catchment has been developed for residential, commercial and industrial purposes. In the immediate vicinity of the Motorway, on the upstream side, there are several low lying paddocks and a number of houses, with industrial development on the downstream side. Under the 100 year ARI flood event, substantial inundation of the land adjacent to the Gateway Motorway occurs (refer Figure 1). This specifically impacts on a number of the upstream residences.

The GUP requires the construction of additional lanes on the downstream (eastern) side of the Bulimba Creek bridge crossing. The proposed works involve the following:

- Construction of a new bridge and filled embankments along the alignment of the new lanes;
- Additional piers to support the bridge duplication; and
- Reinforcing of the existing bridge piers to support additional lanes on the existing structure.

The upgrade works also require bridging of the two minimum energy culverts of Bulimba Creek and Minnippi Channel. All of the required works are assessed in more detail in the following sections.

3.2 Cleveland Branch Rail Line to Pinkenba Rail Line

From Lytton Road, the alignment crosses the Brisbane River adjacent to the existing bridge crossing and then passes through the Royal Queensland Golf Course and industrial land in the vicinity of Kingsford Smith Drive. The alignment then crosses further industrial land over the Pinkenba Rail Line.

The Brisbane River is the largest river flowing into Moreton Bay and the principal river potentially affected by the GUP. Areas along the Brisbane River have been cleared and developed over many decades. In the 1940s the river mouth and river bed itself were first dredged, leading to increased tidal penetration. In the mid- to late 1990s this dredging ceased. The 100 year ARI Brisbane River event flood inundation is contained within the riverbanks. Taking this into account and the fact that the new Gateway bridge piers will be aligned with that of the existing bridge, the new bridge crossing should not significantly impact upon flood levels or flow distribution and therefore has not been the subject of a detailed investigation.

3.3 Pinkenba Rail Line to Nudgee Road

This portion of the GUP alignment crosses the lower reaches of Kedron Brook Floodway. The GUP alignment deviates substantially from the existing Motorway alignment and as such introduces a number of new waterway crossings. The alignment passes through the TradeCoast Central (TCC) site, on to Brisbane Airport land and finally crosses Kedron Brook Floodway before linking up with the existing Gateway Motorway at Nudgee. Existing surface water features in this area include:

- Kedron Brook Floodway;
- Tidally influenced engineered channels and remnant streams;
- Freshwater channels and remnant streams;
- Remnant mangrove and saltmarsh/claypan;
- Remnant freshwater wetlands; and
- Manmade freshwater lakes and semi natural freshwater lagoons.

Figure 2 outlines the major tributaries and waterways within the proximity to the GUP and in the surrounding region. Within the Brisbane Airport precinct, a network of minor waterways drain into larger, highly engineered channels, including Landers Pocket Drain and a part of Schulz Canal before draining east and north to the Kedron Brook Floodway. The floodway is an engineered waterway that carries runoff from the Kedron Brook catchment into Moreton Bay immediately north of the Brisbane Airport and is 6km long and up to 4m deep at high tide. Constructed during the depression to link Kedron Brook and Serpentine Creek, Schulz Canal was restructured with the Kedron Brook Floodway in the early 1980s as part of the Brisbane Airport redevelopment. Schulz Canal enters Kedron Brook Floodway at the start of the floodway.

Under the 100 year ARI event, extensive overbank flooding occurs on Kedron Brook Floodway, inundating a vast majority of the GUP corridor to the north of the Pinkenba Rail Line and to the east of the existing Gateway Motorway. A number of residential and commercial properties in this area are inundated during this flood event. Therefore, it is important that the proposed road structure does not increase existing flood levels.

The Kedron Brook Catchment Management Plan, prepared by BCC, records that 1,160 properties were inundated in 1974, and that creek flooding is an important issue in this catchment. Some of the strategies identified for the catchment in relation to flooding include:

- Continued monitoring of the FRLs;
- Maintaining flood height gauges in the catchment;
- Identification of areas where the cross sectional area of the Brook has been reduced due to siltation; and
- Restoration to the previous capacity as part of ongoing creek maintenance.

The GUP requires the construction of a new roadway embankment through this section including minor and major cross drainage elements. The proposed drainage works involve the following:

- Provision of cross-drainage within the Trade Coast Central site;
- Provision of cross-drainage within Brisbane Airport; and
- Construction of a new bridge crossing of Kedron Brook Floodway.

The bridge crossing of Kedron Brook Floodway is investigated in more detail in the following sections. At this stage allowances have been made for cross-drainage under the alignment to cater for runoff from both Trade Coast Central and Brisbane Airport. The size and location of these structures have been selected to minimise potential impacts on existing drainage flowpaths. It is suggested that this provision be discussed further with both parties in the detailed design stage when layouts for both development sites may be more clearly defined.

4. Hydraulic Analysis

4.1 General

Flood impact modelling for the study was undertaken using the MIKE 21 software package, developed by DHI Water and Environment. MIKE 21 is intended for the simulation of hydraulic and related phenomena in two-dimensional free-surface flow situations. Two-dimensional modelling uses a topographic surface (or terrain model) to accurately represent flowpaths, and was considered necessary due to the large degree of overbank inundation that occurs during flood events, particularly for Bulimba Creek. On Kedron Brook Floodway, this modelling approach enabled accurate modelling of the skewed bridge crossing.

The hydraulic analysis was conducted using steady-state conditions representing the peak flood conditions at the Gateway Motorway crossings of Bulimba Creek and Kedron Brook Floodway. The modelling was undertaken for the purposes of:

- Determining Base Case peak flood levels for the 100 year ARI event;
- Determining the impacts (afflux) resulting from the structures introduced by the Gateway Upgrade Project; and
- Assessing the effectiveness and impact of a range of flood mitigation schemes.

Separate MIKE 21 hydraulic models were developed for the Bulimba Creek and Kedron Brook Floodway investigations. The models are described below in Sections 4.3 and 4.4, respectively.

In addition, detailed one-dimensional hydraulic models were developed for the minimum energy loss culverts across the Gateway Motorway in the Bulimba Creek area using HEC-RAS, a hydraulic analysis package developed by the Hydraulic Engineering Centre of the US Army Corps of Engineers. This modelling was undertaken for the purposes of:

- Examining the impact of possible modifications to the culverts required for the duplication of the existing Gateway Motorway; and
- Confirmation of the accuracy of the representation of the culverts within the Bulimba Creek MIKE 21 model.

4.2 Modelling Approach

Impacts on flood levels resulting from the Gateway Upgrade Project and the mitigation measures were assessed against Base Case conditions. As with the hydraulic modelling conducted during the Planning Study, the Base Case conditions assumed 'ultimate' development of the surrounding catchments. The key aspects of this approach were:

- Design discharges are the ultimate development flowrates resulting from planned ultimate urbanisation and development within the catchment;
- The terrain models used in the modelling assumed ultimate development along Bulimba Creek up to the Flood Regulation Line (FRL) boundaries set by Brisbane City Council. FRLs define the waterway corridor for each creek and limit the extent and encroachment of development in this area. All areas outside the FRL were therefore excluded from the MIKE 21 model calculations; and
- Structures not inundated by the 100 year ARI flood levels (ie the gateway motorway crossings) were modelled using MIKE 21 internal pier resistance routines. Smaller hydraulic structures were modelled using MIKE 21 structure routines (level-area relationship) and calibrated against existing one-dimensional hydraulic models.

4.3 Bulimba Creek Hydraulic Modelling

The Bulimba Creek model is centred on the Gateway Motorway crossing of Bulimba Creek, and covers an area from the Meadowlands Picnic Ground in the south to Hemmant Recreation Reserve in the north.

4.3.1 Model Topography

The topographic surface map for the Bulimba Creek model covers a length of Bulimba Creek from approximately 4.4km upstream of the Gateway Motorway crossing to 4.9km downstream, as shown in Figure 3. Major overflow bypasses such as the Minnippi bypass at Tingalpa and the minimum energy loss (MEL) culvert on the southern overbank of Bulimba Creek are included in the model. There are six hydraulic structures within the model area, including:

- The Gateway Motorway bridge crossing of Bulimba Creek;
- Two minimum energy loss (MEL) culverts underneath the Gateway Motorway – one on the southern overbank of Bulimba Creek, and one in Tingalpa to the south of Wynnum Road (part of the Minnippi bypass);
- Two bridge/culvert structures along Wynnum Road (Bulimba Creek and Minnippi bypass crossings); and
- The Murarrie Road bridge across Bulimba Creek, upstream of the Gateway Motorway viaduct.

The model covers an area of approximately 2.3km × 3.75km at a grid spacing of 5m. The grid spacing was considered to provide sufficient definition for the major flowpaths, including the Minnippi bypass channel and the MEL culvert fans. The alignment of the topographic map was The data was rotated approximately 6.5° so that the principal flow in Wynnum Road and Murarrie Road structures was orthogonal to the grid in the MIKE 21 model, a requirement for the implementation of level-width structures into MIKE 21. Areas outside the flood regulation lines were excluded from the computational grid.

4.3.2 Modelling and Calibration of Hydraulic Structures (Bridges and Culverts)

The Gateway Motorway bridge across Bulimba Creek is the primary focus of this investigation. This structure is complicated by the fact that the Bulimba Creek passes beneath the Motorway at an angle of approximately 45º. Overbank flow however passes through the structure at a more orthogonal angle. Conventional one-dimensional structure routines would not well-represent model the complex flow patterns through the bridge.

Preliminary investigations indicated that the 100 year ARI flood level does not reach the soffit of the bridge crossing. These conditions strongly advocated the use of the MIKE 21 pier resistance function to model the bridge piers, with the bridge embankments modelled as part of the topographic map and the bridge pier resistance implicitly calculated using MIKE 21's pier routines. Using this method, the resistance to the flow due to the piers is modelled by calculating the current induced drag force on each individual pier and equating this force with a shear stress contribution compatible with the MIKE 21 momentum formulation, which is then applied to the relevant grid cell. The existing Gateway Motorway crossing was modelled assuming 1.2m × 0.5m rectangular piers. MIKE 21 pier routines contain an internal table of drag coefficients, which is adjusted to allow for the angle of the pier relative to the flow direction.

The proposed duplication of the Gateway Motorway Bulimba Creek bridge crossing was modelled by increasing the width of the embankment (as per the design plans) and placing additional circular piers (1.2m diameter) downstream of the existing piers. The existing bridge piers were widened at a series of intervals above ground level the to model the proposed reinforcement required to support the modifications to the existing bridge deck.

The minimum energy loss culverts across the Gateway Motorway are relatively large structures (in terms of area). They feature large, streamlined inlet and outlet fans to smooth the contraction and expansion of the flow into and out of the culverts, thereby minimising hydraulic losses. The modelling of these culverts within the Planning Study MIKE 11 model was simplistic, and could not be relied upon for calibration of the MIKE 21 model. Detailed one-dimensional hydraulic models of the MEL culverts were developed using HEC-RAS, and were used to validate the representation in the MIKE 21 model. Using these models, it was found that the 5m grid used in the topographic map could be used to represent the MEL culvert configuration with good accuracy.

The Wynnum Road and Murarrie Road structures were modelled using MIKE 21's implicit structure routine. This is a relatively simplistic method that represents 'structures' as a level-area relationship, with expansion and contraction losses applied to the discharge. These structures were completely drowned under the design 100 year ARI event. Loss coefficients applied to the structures were based on experience, and were found to have negligible impact on the model results.

4.3.3 Boundary Conditions

The MIKE 21 hydraulic modelling was undertaken for the 100 year ARI flood event assuming steady-state conditions, using Bulimba Creek discharges extracted from the MIKE 11 one-dimensional model used for the Planning Study. An inflow of 450m³/s was adopted at the upstream boundary. Additional flows, also taken from the Planning Study model, were added in six locations along the reach of the river to account for additional flow entering the channels via drains, tributaries etc.

A tailwater level of 2.29m AHD was adopted at the downstream boundary to match levels with the Planning Study MIKE 11 model.

4.3.4 Model Calibration

Calibration of the MIKE 21 model was conducted by comparing 100 year ARI peak water levels extracted from the Base Case model results against peak flood levels from the MIKE 11 model used in the Planning Study (which, according to available documentation, had reputedly been validated against recorded flood events). Calibration was accomplished by adjusting the roughness map adopted for the MIKE 21 model till a satisfactory match of levels was achieved. Resistance values were initially selected based upon the values adopted by the MIKE 11 model. The resistance factor adopted for one-dimensional models such as MIKE 11 or HEC-RAS generally includes components for roughness losses, expansion and contraction losses, change of direction etc. These losses are formulated separately in MIKE 21, hence the resistance factors represent only roughness losses and therefore be lower than the one-dimensional factors. The final resistance values adopted are listed in Table 1.

Table 1 Resistance Values Adopted for Bulimba Creek

Land Usage	Manning's n (s/m$^{1/3}$)
Bulimba Creek Channel	0.03
Minnippi Channel	0.04
Overbank	0.04 – 0.08
Mangroves	0.09 – 0.12
Overland (Minnippi Parklands)	0.12

Comparison of the results from the two models is provided in Table 2. Some difference is evident between the two models, however the differences are not consistently high or low.

Examination of the Bulimba Creek flow patterns indicates that, under large flood events such as the 100 year ARI event modelled, there is significant overbank flow and the flow distribution is highly two-dimensional. Although a number of cross-links are provided in the MIKE 11 model, allowing overbank flow to bypass the meanders of Bulimba Creek, it is difficult for this one-dimensional model to accurately represent the two-dimensional distribution of flow that occurs under large flood events. The two-dimensional model should therefore prove more reliable.

Since the objective of this investigation is to compare (and minimise) impact relative to Base Case conditions, it is not considered imperative to obtain an exact match, and the calibration results are considered acceptable. The comparison is also presented graphically on Figure 4.

Table 2 Bulimba Creek Calibration Results

MIKE 11 Model Chainage (m)	MIKE 21 Grid Reference (x,y)	Modelled Water Surface Level (m AHD)		Elevation Difference (m)
		MIKE 21	MIKE 11	
22,775	(207,100)	4.76	4.67	-0.09
25,515	(53,336)	4.06	4.24	0.18
26,620	(117,478)	3.35	3.41	0.06
26,983	(149,533)	3.05	3.24	0.19
29,075	(289,540)	2.65	2.67	0.02
31,605	(414,688)	2.37	2.32	-0.05
1,015 (Minnippi)	(303,304)	4.18	3.82	-0.36
223 (Murarrie)	(221,461)	3.07	3.33	0.26

4.4 Kedron Brook Floodway Hydraulic Modelling

The Kedron Brook Floodway hydraulic model covers a 5km length of Kedron Brook Floodway, centred on the proposed Gateway Motorway crossing, from the existing Gateway Motorway crossing in Nundah to a point just downstream of the Nudgee Golf Course.

4.4.1 Model Topography

The topographic map for the Kedron Brook Floodway model was generated from the DTM model discussed in Section 2.2. A grid spacing of 5m was adopted to provide good representation of the Kedron Brook Floodway channel, which is typically between 40m and 90m wide, and to allow detailed modelling of the proposed crossing structure. The survey data was rotated 53.3° so that the principal flow in the MIKE 21 model was orthogonal. The rotation was carried out about coordinate Easting 8690, Northing 170025.

The Kedron Brook Floodway model covers an area of approximately 5.9km × 2.3km, although much of this area is outside the Flood Regulation Lines and therefore excluded from the computational grid. The model contains approximately 5km of Kedron Brook Floodway (2.2km upstream of the proposed crossing and 2.8km downstream) as well as Cannery, Pound and Battery Drains up to the boundaries of the Kedron Brook Floodway Flood Regulation Lines. The model extent of Kedron Brook Floodway is presented in Figure 5.

4.4.2 Modelling and Calibration of Hydraulic Structures (Bridges and Culverts)

There are no existing hydraulic structures on the length of Kedron Brook Floodway that is under consideration. The existing Gateway Motorway crossing in Nundah is at the upstream boundary of the model.

There are some small crossings of Cannery, Pound and Battery Drains, such as bikeway/pedestrian bridges. These are typically perpendicular to the primary direction of flow during Kedron Brook flood events and are drowned out during large flood events. It is anticipated that they would have negligible impact on flood levels and therefore these structures were not included in the hydraulic model.

The proposed GUP bridge crossing has been designed with the bridge soffit clear of the 100 year ARI flood level. Consequently, the proposed bridge was modelled using MIKE 21's pier resistance routines, with the embankment modifications modelled as part of the topographic data. The main Kedron Brook Floodway crossing was modelled assuming 2.0m × 3.4m elongated circular piers or 3.0m diameter circular piers depending upon the mitigation option (see Section 6.3), while 2.4m diameter circular piers were assumed for the northern bifurcation. Refer to Section 4.3.2 for discussion on MIKE 21 pier resistance modelling.

A number of assumptions have been made in the modelling process including the following:

Northern Bifurcation and Main Crossing

- The pier cross-section is assumed to be uniform for its entire height;
- Pier Streamline factor adopted is 1.05 (this is a factor to account for increased velocity due to blockage of piers);
- For Main Crossing flow is generally parallel to the pier alignment.

4.4.3 Boundary Conditions

The MIKE 21 hydraulic modelling was undertaken for the 100 year ARI flood event assuming steady-state conditions. Peak discharges used in the hydraulic model were taken from the Kedron Brook Flood Study (Connell Wagner, 1996). The peak discharge at the upstream boundary (the existing Gateway Motorway crossing) was 704m^3/s, with two additional inflows included along the reach modelled to represent inflows from side tributaries/drains. A tailwater level of 1.59m AHD was obtained from the Kedron Brook Flood Study and adopted at the downstream boundary. This combination of boundary conditions formed the Base Case scenario.

4.4.4 Model Calibration

Calibration of the MIKE 21 model was carried out by comparing water levels extracted from the Base Case model results with peak flood levels taken from the HEC-RAS model used in the Planning Study, and was accomplished by adjusting the roughness map adopted for the MIKE 21 model. Resistance values adopted for the model are listed in Table 3.

Table 3 Resistance Values Adopted for Kedron Brook Floodway

Land Type	Manning's n (s/$m^{1/3}$)
Downstream Channel	0.03
Upstream Channel	0.025
Overbank	0.035
Mangroves	0.07

Comparison of the MIKE 21 model level predictions with the HEC-RAS model is provided in Table 4 and are presented graphically on Figure 6. The maximum elevation difference between the two models is approximately 60mm, near the downstream end of the MIKE 21 model. Minor differences between one-dimensional and two-dimensional model results are not uncommon, and the comparison listed in Table 4 is considered to be a reasonable match.

Table 4 Kedron Brook Floodway Calibration Results

HEC-RAS Model Chainage (m)	MIKE 21 Grid Reference (x,y)	Modelled Water Surface Level (m AHD)		Elevation Difference (m)
		MIKE 21	HEC-RAS	
130	(1126, 269)	1.79	1.85	-0.06
170	(940, 290)	2.28	2.30	-0.02
210	(740, 270)	2.70	2.71	-0.01
280	(562, 257)	3.00	3.01	-0.01
310	(352, 268)	3.12	3.07	0.05
340	(338, 282)	3.13	3.09	0.04

5. Bulimba Creek Modelling Results

5.1 Base Case Flood Conditions

Peak water surface levels and depths in the Bulimba Creek area for the Base Case 100 year ARI design event are shown in Figures 7a and 7b respectively. Velocity vectors are included in Figure 7a indicating the flow speed and direction. It is evident from these Figures that there is significant overbank flow and that the flow distribution is highly two-dimensional. There are three areas of relatively high hydraulic loss leading to significant changes in water surface levels. These include:

- Beneath the Gateway Motorway crossing of Bulimba Creek (1 to 2m/s);
- At and downstream of the Wynnum Road crossing of Bulimba Creek (up to 2m/s); and
- At the Wynnum Road crossing of the Minnippi Bypass (up to 3m/s).

Due to the large overbank component, velocities are generally low (< 1m/s), with the exception of:

- Downstream of the Wynnum Road crossings (Bulimba Creek and Minnippi bypass) (< 2.25m/s);
- Downstream of the Gateway crossing of Bulimba Creek (< 1.7m/s); and
- Through the MEL culverts (< 2.5m/s).

It should be noted that the velocities through the Bulimba Creek bridge are relatively low (< 1m/s). As expected, the major flow direction is along the creek, which passes beneath the viaduct at an angle of approximately 45º. The flow direction on the overbank beneath the viaduct is almost perpendicular to the crossing.

An area of shallow flow depth and high velocity (relative to most overbank flow) can be observed on the eastern overbank immediately to the south of the viaduct piers (refer Figures 7 and 8). This can be directly related to an area of dumped fill, which is believed to have been dumped illegally and appears to present a impediment to flow beneath the bridge. A smaller area of illegal fill exists immediately to the north of these piers, also impeding the flow downstream. In total the plan area of illegal fill upstream and downstream amounts to approximately 0.55ha.

An Alternate Base Case MIKE 21 model run was carried out to determine the impact of the dumped material on Bulimba Creek flood levels. The area of illegal fill was removed and ground levels set to those of the surrounding areas (around RL 1.2m AHD). When compared to the original Base Case peak water levels, flood levels immediately upstream of the existing Gateway Motorway, were up to 60mm lower for the Alternate Base Case and up to 10mm lower at Wynnum Road. The Peak water surface levels and depths in the Bulimba Creek area for the Alternate Base Case 100 year ARI design event are shown in Figures 8a and 8b respectively. Velocity vectors are included in Figure 8a indicating the flow speed and direction.

From discussions with MR, it was determined that this illegal fill would be removed as part of the GUP works. It was therefore appropriate to adopt the Alternate Base Case as the scenario against which to compare all Mitigation Option Results.

5.2 Impact of the Gateway Upgrade Project Works

The proposed Gateway Motorway requires the construction of additional lanes on the downstream (eastern) side of the bridge. The proposed works require the following modifications to the Bulimba Creek model:

- Construction of new bridge and filled embankments along the alignment of the new lanes;
- Additional piers to support the bridge duplication. These were initially modelled assuming the sizes and locations specified in the Planning Study; and
- Reinforcing of the existing bridge piers to support additional lanes on the existing structure.

It has been assumed that the overpasses across the MEL culverts will be designed to avoid impacting on the performance of these structures and this is discussed in more detail in Section 7.

Changes in water level (ie afflux) due to the proposed GUP works are shown in Figures 9a and 9b. Figure 9a compares the Developed Case results to the Base Case results, whilst Figure 9b compares the Developed Case results to the Alternate Base Case result. Both of these plots have been prepared to allow comparison against the impacts estimated during the Planning Study.

Figure 9a shows that the major impacts are caused by the modifications to the existing piers and the construction of additional piers at the Gateway Motorway crossing. The maximum afflux, just upstream of the viaduct, is approximately 30mm. The afflux dissipates with distance from the crossing. The afflux at Wynnum Road is typically less than 5mm. Further upstream, downstream of the Gateway Motorway, and along the Minnippi bypass the afflux is typically within $\pm$5mm.

For comparison, the Planning Study estimated an afflux of approximately 60mm upstream of the viaduct and 25mm at Wynnum Road, dissipating to zero near the upstream end of the MIKE 21 model. However, the Planning Study report states that the MIKE 11 modelling was likely to overestimate the impacts of the new structure, particularly because of the two-dimensional flow patterns at the viaduct.

As discussed above, illegally dumped material has a significant impact on modelled flood levels. The proposed duplication works have been modelled with the illegal material. This has been compared to the Alternate Base Case and the comparison is presented in Figure 9b, the afflux is approximately 20mm immediately upstream of the bridge, reducing to less than 5mm afflux at Wynnum Road Bridge. These affluxes are generally 40% lower than the affluxes observed without the illegal fill removed.

The reduced impacts can be directly related to the increased conveyance through the overbank sections of the viaduct opening, which has the effect of:

- Reducing the overall velocity of the flow, which lowers the effect of drag resistance of the piers (pier resistance is proportional to the square of the velocity); and
- Increasing the proportion of overbank flow, thereby reducing the impact resulting from the reinforcement of the existing viaduct piers located in the middle of Bulimba Creek.

5.3 Mitigation Options Assessment

A number of options have been identified to minimise and/or mitigate the impact of the development. The following mitigation options have currently been assessed:

Option 1 – Skewing of the piers of the viaduct duplication to align with the flow direction and locate the piers on the creek banks; and
Option 2 – Earthworks carried out in the vicinity of the Bulimba Creek Bridge.

The impacts of the proposed mitigation works are discussed in the following sections.

5.3.1 Mitigation Option 1 – Impact of the Skewed Viaduct Piers

The afflux resulting from the proposed development assuming that the viaduct duplication piers are skewed piers is shown in Figures 10a and 10b as compared to the Base Case and Alternate Base Case respectively. On Figure 10a the maximum afflux is less than 40mm, reducing to 5mm upstream of Wynnum Road. On Figure 10b the maximum afflux is less than less than 20mm, reducing to less than 5mm at Wynnum Road.

The mitigation option results show minor improvement (approximately 5%) over the original pier alignment. This suggests that:

- Skewing the piers offers minimal hydraulic improvement. However, it will avoid construction of piers in the channel and will streamline flood flows. This will be more critical for events greater than the 100 year ARI event where the velocities may be higher; and
- Much of the hydraulic impact of the proposed works results from the reinforcement of the existing piers, particularly the two piers that currently lie within Bulimba Creek.

Based on these observations, skewing the viaduct piers offers minor hydraulic advantages but does not eliminate the impact of the duplication works, and additional mitigation is required. However, the skewed alignment is preferable with regard to the placement of the piers relative to the creek, and has therefore been adopted in conjunction with other mitigation options.

5.3.2 Mitigation Option 2 – Impact of Localised Earthworks

Mitigation Option 1 still shows an increase in flood levels of up to 20 to 40mm, depending upon whether or not the illegal fill material is removed. Additional earthworks would be required to fully mitigate the impact of the duplication. Figure 11 shows the impacts of Mitigation Option 2 and the area of proposed further earthworks (total area – 1.16ha) on flood levels when compared to the Alternate Base Case.

The proposed earthworks generally lower overbank levels to approximately RL 1.2 m AHD and result in a general reduction in levels upstream and a minor local increase in levels downstream. Localised afflux of approximately 20mm is observed in the area of the earthworks – the increase in levels is likely the side-effect decreased velocities in the area[1].

5.4 Summary of Mitigation Options and Outcomes

At the Bulimba Creek crossing, a number of options have been considered to mitigate the impact of the proposed GUP works. The recommended works are those detailed in Mitigation Option 2 and include:

- Removal of the illegal fill material as defined in Figure 7b;
- Skewing of the bridge piers to streamline flow patterns and avoid locating one of the piers directly across the creek channel;
- Localised earthworks as defined in Figure 11.

This combination of works minimises the impact of the proposed works and limits any increase in flood level to the immediate vicinity of the bridge site.

[1] Total energy at any location is the sum of potential energy (depth) and kinetic energy (velocity). If velocities in an area are reduced, such as by increasing the conveyance area, the flow depth must increase.

6. Kedron Brook Floodway Modelling Results

6.1 Base Case Flood Conditions

Peak water surface levels and depths in the Kedron Brook area for the Base Case 100 year ARI design event are shown in Figures 12 and 13 respectively. Velocity vectors are included in Figure 12 to indicate the relative speed and direction of flow.

As presented in Figure 12, the flow patterns differ quite significantly upstream and downstream of the deeper floodway channel. Upstream of the transition fan the conveyance area of the channel is less and hence there is deep overbank flow. Due to the large overbank component velocities are generally low in this area, ranging from approximately 0.4m/s on the floodplain to approximately 1m/s in the channel. As the conveyance area of the channel downstream of the transition fan increases significantly, a reduction in overbank flow occurs. The velocities in the channel increase to approximately 2m/s while overbank velocities reach approximately 0.3m/s. These results are presented in Figure 12.

6.2 Impact of the Gateway Upgrade Project Works

The proposed works in the Kedron Brook Floodway corridor for the GUP consists of the construction of a new bridge crossing and the Northern Bifurcation ramp. A small area of the roadway embankment encroaches into the waterway on both sides of the creek. The piers for the Kedron Brook Floodway crossing and the Northern Bifurcation were modelled according to the dimensions and coordinates specified in the Planning Study.

The effects of the proposed works have been analysed in a stepped procedure, ie the effects of the embankments alone, the effects of bridge piers alone and a combination of both. The afflux due to the embankments alone is approximately 5mm, which extends a approximately 1600m upstream. The afflux due to piers alone is approximately 15mm also extending approximately 1600m upstream. The effects of the entire proposed works (ie Developed Case) are presented in Figure 14. These proposed works increase water levels immediately upstream of the crossing by approximately 15mm, which decreases to 10mm at the Battery Drain confluence. The afflux at the current Gateway Motorway crossing is approximately 6mm.

6.3 Mitigation Options Assessment

Several mitigation options have been considered, separately and in combination, to offset the impact of the proposed GUP works, including:

- Modification of the shape of the bridge piers – The original piers had an elongated circular shape and were 2.0m wide and 3.4m deep (in the direction of flow). Model runs were undertaken with the pier width on the overbank areas being reduced to 1.5m and all other dimensions unchanged. In addition, a model run examining the impact of adopting 3m diameter circular piers was carried out.
- Adjustment of pier spacing – A series of mitigation options involving the adjustment of the spacing of the bridge piers across the Kedron Brook Floodway channel were carried out. The original pier spacing was 50m. A wider pier spacing of 70m was considered to move the piers away from the high velocities in the floodway channel.
- Realignment of the Flood Regulation Lines – Adjustment to the Flood Regulation Line on the southern side of the floodway channel was assessed. The current FRL follows the Brisbane Airport Corporation (BAC) property boundary in this area. A review of the current BAC Master Plan was undertaken and a potential adjustment to the FRL was developed. This proposal involved movement of the current FRL by between 0 and 150 metres – essentially flattening the curved FRL in this area.

- Compensatory earthworks downstream of the proposed crossing – Varying depths of earthworks between 0.3m and 1.0m were assessed. The location of the earthworks was selected from review of the MIKE 21 model results which indicated areas of shallow or no flow. In addition, consideration of environmental concerns for fauna along the waterway corridor were taken into account when selecting appropriate locations for potential earthworks. The proposed earthworks are located on the northern side of the floodway, as environmental concerns restricted the option on the southern side. The extent of earthworks considered is presented on each figure presenting the Mitigation Option results as detailed in Table 5 below.

The following sections detail the outcomes from each of the Mitigation Option MIKE 21 model runs.

6.3.1 Mitigation Option 1 – Original Pier Shape, Altered Pier Spacing

The afflux for Mitigation Option 1 is presented in Figure 15. This shows the variation in peak water level as compared to the Base Case peak water levels. There is an increase of up to 10mm as a result of the adjusted pier spacing, decreasing to approximately 5mm at the current Gateway crossing. The proposed alteration of the pier spacing leads to a drop in afflux of approximately 5mm.

6.3.2 Mitigation Option 2 – Adjustment to the FRL

Mitigation Option 2 includes adjustment of the Flood Regulation Line (FRL) on the southern side of the floodway. Figure 16 presents the difference in levels between this case and the Base Case. There is an increase of 4 to 6 mm, decreasing to close to 2mm by the location of the current Gateway crossing. Therefore it can be seen that adjusting the FRL reduces the afflux by approximately 10mm.

6.3.3 Mitigation Option 3 – Pier Spacing and FRL Adjustment

Mitigation Option 3 includes the 70m pier spacing and the adjusted FRL. Figure 17 presents the difference in levels between this case and the Base Case. The afflux in the floodway channel is generally between 1 to 2mm and drops to close to zero near the current Gateway crossing.

6.3.4 Mitigation Option 4 – Pier Spacing and FRL Adjustment, and Earthworks

Mitigation Option 4 includes 70m pier spacing, the adjusted FRL and earthworks on the northern bank of the floodway channel within the FRLs. It can be seen from Figure 12 that on the northern bank downstream of the bridge crossing that there are dry areas or areas of shallow flow. Earthworks have been included in this area to a depth of 1m with the extent shown on Figure 18.

Figure 18 presents the difference in levels between this case and the Base Case. The results when compared to the Base Case show a global decrease in levels upstream of over 15mm. To evaluate the impact of the earthworks in isolation Figure 18 should be compared against Figure 17. It can be seen that the earthworks have a significant impact on afflux. Comparing Figures 17 and 18 shows a drop in flood levels of over 20mm as a result of the 1m deep excavation.

6.3.5 Mitigation Option 5 – Pier Spacing and FRL Adjustment, and Earthworks

In Mitigation Option 5 the depth of excavation associated with the earthworks reduced to 0.3m deep and cover the extent shown in Figure 19. Figure 19 also presents the afflux as compared to the Base Case. There is a decrease in levels immediately upstream of the proposed Gateway crossing of approximately 5mm, decreasing to almost zero at the Battery Drain confluence. When the earthworks are assessed in isolation they reduce levels by up to 5mm.

6.3.6 Mitigation Option 6 – Pier Spacing and FRL Adjustment, and Earthworks

In Mitigation Option 6 the depth of excavation associated with the earthworks reduced to 0.1m deep and covers the extent shown in Figure 20. Figure 20 also presents the afflux as compared to the Base Case. These works result in an afflux immediately upstream of the proposed Gateway crossing of approximately 3mm, decreasing to 1mm at the Battery Drain confluence, showing this extent of earthworks is not sufficient. When these earthworks are assessed in isolation they reduce levels by up to 2mm.

6.3.7 Mitigation Option 7 – Adjusted Pier Widths and Earthworks

Mitigation Option 7 includes the original pier shapes and spacing with the overbank pier widths reduced to 1.5m. Also included are earthworks to a depth of 0.3m over the area shown in Figure 21. The results, when compared to the Base Case, show an increase in levels of 10mm immediately upstream of the bridge decreasing to 8mm at the Battery Drain confluence.

6.3.8 Mitigation Option 8 – Adjusted Pier Widths and Earthworks

Mitigation Option 8 includes the original pier shapes and spacing with the overbank pier widths reduced to 1.5m. Also included are earthworks to a depth of 1.0m over the area shown in Figure 22. The results when compared to the Base Case show a decrease in levels of 15mm immediately upstream of the bridge decreasing to 8mm at the Battery Drain confluence.

6.3.9 Mitigation Option 9 – Adjusted Pier Widths and Broader Earthworks Extent

Mitigation Option 9 includes the original pier shapes and spacing with the overbank pier widths reduced to 1.5m. Also included are earthworks to a depth of 0.3m over the area shown in Figure 23. The extent of earthworks has been extended as compared to Mitigation Option 7. The results compared to the Base Case are presented in Figure 23 and show an increase in levels of approximately 4mm immediately upstream of the proposed crossing continuing to the Battery Drain confluence.

6.3.10 Mitigation Option 10 – Adjusted Pier Widths and Broader Earthworks Extent

Mitigation Option 10 includes the original pier shapes and spacing with the overbank pier widths reduced to 1.5m. Also included are earthworks to a depth of 0.5m over the area shown in Figure 24. The results compared to the Base Case are presented in Figure 24 and show a reduction in levels of 4mm upstream of the proposed crossing reducing to zero afflux further upstream at the Battery, Pound and Cannery Drain confluences.

6.3.11 Mitigation Option 11 – Circular Piers and Broadened Earthworks Extent

Mitigation Option 11 includes 3m circular piers at the original 50m pier spacing, with the wider extent of earthworks to a depth of 0.5m as shown on Figure 25. The results of Option 11 as compared to the Base Case are presented in Figure 25. Immediately upstream levels are reduced by 8mm, decreasing to 2mm at the Battery, Pound and Cannery Drain confluences.

6.4 Summary of Outcomes

The combination and extent of the mitigation options assessed as part of this investigation are summarised in Table 5. Also presented is a summary of the peak affluxes for each option. The analysis undertaken has shown that mitigation of the GUP impacts can be achieved through a number of options. This includes adjustment of the FRL, localised earthworks, adjustments to pier shape and spacing or a combination of the preceding elements.

Taking into account the complete GUP works and what is involved in achieving the proposed Mitigation Options, it is proposed that Mitigation Option 10 be adopted at this stage for the Kedron Brook area. It is anticipated that the soil that is removed can be used on the GUP and no works are required on property other than that under the control of BCC. In addition, there are no environmental concerns with the excavation proposed under Mitigation Option 10.

Under the options considering localised earthworks, there is generally a localised increase in flood levels downstream of the bridge site, near the start of the Nudgee Golf Course. This localised impact is limited to approximately 20mm under Mitigation Option 10 and does not impact on any waterways that drain under the Gateway Motorway. This localised increase should not adversely impact on the golf course as in reality, flood waters would spread in this area and inundate the golf course (ie the FRL is not a physical barrier to flood waters).

Table 5 Summary of Kedron Brook Floodway Mitigation Options and Outcomes

Mitigation Option	Figure No	Pier Shape	Pier Spacing (m)	FRL Realignment	Compensatory Earthworks	Peak Afflux (mm)
1	15	Original	70	✗	✗	+10
2	16	Original	50	✓	✗	+6
3	17	Original	70	✓	✗	+2
4	18	Original	70	✓	1.0m	-20
5	19	Original	70	✓	0.3m	0 to -5
6	20	Original	70	✓	0.1m	+1 to +3
7	21	Width Adjusted	50	✗	0.3m	+8 to +10
8	22	Width Adjusted	50	✗	1.0m	-10 to -15
9	23	Width Adjusted	50	✗	0.3m[a]	+4
10	24	Width Adjusted	50	✗	0.5m[a]	-4 to 0
11	25	Circular	50		0.5m[a]	-8 to -2

Notes: a Earthworks over a larger area than Option 7, ✓ - Yes, ✗ = None or not applicable.

7. Bulimba Creek MEL Culverts

7.1 General

The Gateway Motorway duplication crosses two Minimum Energy Loss (MEL) culverts which form part of the Bulimba Creek system. The first MEL culvert is located on the eastern overbank of Bulimba Creek (Ch 14260), approximately 500m from the bridge crossing of the creek, and provides additional conveyance for breakout flow from the main channel beneath the Gateway Motorway.

Further upstream, under larger flood events, flow breaks out from Bulimba Creek across the Minnippi parklands on the eastern side of the creek upstream of Wynnum Road. This overflow passes through a second MEL culvert under the Gateway Motorway (Ch 13100), south of the Wynnum Road off-ramp, and flows northwards in an overflow channel to rejoin Bulimba Creek. The bypass route is referred to as the 'Minnippi bypass', and the MEL structure as the 'Bulimba Creek Overflow Culvert'.

7.2 Characteristics of the MEL Culverts

Afflux (increase in water level upstream relative to downstream) is typically the result of hydraulic energy losses across the structure. This loss is a combination of expansion and contraction losses, form loss (drag) and surface friction loss. A MEL culvert is a structure specifically designed to minimise these hydraulic losses. It has a number of unique features compared to a regular culvert, of which the two most obvious are:

- The inlet and outlet fans of the structure are fully streamlined. This significantly reduces expansion, contraction and form losses. The hydraulic losses across the MEL culvert are primarily friction losses, which in some situations may actually be lower than the 'natural' losses in the floodplain; and
- The invert of the barrel is lower than the upstream and downstream surface levels. This allows the cross-sectional area to be maximised while minimising the barrel width.

7.3 Hydraulic Losses through the MEL Culverts

The MEL culvert design implies that the primary losses in the culvert should be frictional, and that contraction and expansion losses and form losses should be small. Both culverts are somewhat unconventional in that the upstream lip of the inlet fan is higher than the upstream ground level. It is possible that this design is intentional, so that the culverts only becomes operational under large flood events. A consequence of the elevated lip is that culvert inlet acts as a weir when the tailwater levels are low.

Analysis of the Bulimba Creek culverts using both one-dimensional (HEC-RAS) and two-dimensional (MIKE 21) models indicated that the dominant losses are:

- Contraction and weir losses upstream of and at the upstream lip of the inlet fan; and
- Friction losses through the culvert.

The contraction and weir control that occurs at the upstream lip of the fan is the only significant factor for low to moderate discharges, and remains a significant contributor at high discharges.

7.4 Bulimba Creek Overflow Culvert (Minnippi Bypass – Ch 13100) Upgrade

The barrel of the Minnippi Bypass overflow culverts consist of four 3600×3000 Reinforced concrete box culverts (RCBC) units with spanning slabs between the first and second, and third and fourth culverts (ie six openings in total). The total span between the wingwalls is 23.0m.

7.4.1 Gateway Upgrade Project Works

The proposed GUP works require the widening/duplication of lanes crossing the culvert on both the upstream and downstream sides. The realignment of the Wynnum Road off-ramp requires the roadway on the upstream side to be widened by up to 8m, while the duplication of lanes on the southern side requires an additional up to 8m width on the downstream side.

7.4.2 Crossing Support Options

The inlet fan geometry changes quite rapidly close to the culvert inlet. Nevertheless, it should be possible to provide an intermediate support (or supports), provided that these supports match the existing culvert wall thickness. The streamlining of the outlet fan is generally more critical to the performance of an MEL culvert, but the existing geometry changes much more gradually than at the inlet.

The ideal location for an intermediate support is at the centreline to divide the extension into two spans of 11.5m. The symmetry of the fan shape implies that a centralised support would have little impact on streamlining. Alternatively, two supports (three spans of $\approx$7.7m) could be provided if the supports were orientated to streamline flow into the barrel. Provided that the streamlined profiles of the inlet and outlet are maintained, the only impact should be the additional wall friction.

A detailed HEC-RAS model of the MEL culvert was developed to examine the impact of extending the culvert walls. Assuming that the second and fourth culvert walls were extended upstream and downstream (ie two intermediate supports), the maximum afflux upstream of the culvert was 1mm for discharges up to 150m^3/s (the 100 year ARI discharge through the bypass MEL culvert is approximately 108m^3/s).

7.5 Bulimba Creek Overbank Culvert Upgrade (Ch 14260)

The Bulimba Creek Overbank culverts consist of six 1820×1520 RCBC units with five spanning slabs, giving a total span between the wingwalls of approximately 22.5m

7.5.1 Gateway Upgrade Project Works

The proposed duplication works for the GUP require the construction of four additional lanes over the top of the outlet fan of the culvert, with a width of approximately 24m. The upgrade is complicated by the relatively low clearance between the road surface and the soffit of the culvert (approximately 0.9m) giving little thickness for spanning beams.

7.5.2 Crossing Support Options

The existing culvert walls are thinner in this MEL culvert than the Minnippi Bypass MEL culvert and as such there is less opportunity to introduce intermediate supports for the widening works.

8. Conclusions

The proposed GUP works have the potential to impact upon flood levels in a number of adjacent waterways. This is particularly significant for the Kedron Brook Floodway and Bulimba Creek systems where properties are already at risk of inundation under large flood events. It was therefore necessary to fully assess the potential impacts and derive achievable and practical mitigation measures to ameliorate the estimated impacts.

Detailed analysis of the waterways was undertaken through the development of 2-dimensional MIKE 21 hydraulic models of the creek systems. For this investigation the 2-dimensional MIKE 21 modelling was adopted to enable more accurate modelling of the highly complex and meandering Bulimba Creek system and the skewed bridge crossing over Kedron Brook Floodway. The modelling was undertaken for the purposes of:

- Determining Base Case peak flood levels for the 100 year ARI event;
- Determining the impacts (afflux) resulting from the structures introduced by the Gateway Upgrade Project; and
- Assessing the effectiveness and impact of a range of flood mitigation schemes.

The modelling undertaken determined that the proposed GUP works would increase flood levels locally without the introduction of measures to mitigate these increases in peak flood levels. A range of mitigation options have been examined at both crossing locations including:

- Altered pier shapes, sizes, skew angles and spacings;
- Localised earthworks; and
- Movement of FRLs.

The preferred Mitigation Options on both waterways consists of localised earthworks within close proximity to the bridge crossings. On Bulimba Creek removal of illegal fill is also required to improve the hydraulic performance of the bridge crossing. The extent of works proposed are presented in Figures 11 and 24 for Bulimba Creek and Kedron Brook Floodway, respectively.

Consideration of impacts on the MEL culverts on Bulimba Creek was also carried out with potential locations for bridge supports nominated to minimise impacts on the operation of these structures.

Taking into account the fact that the new Brisbane River Gateway bridge piers will be aligned with that of the existing bridge, the new bridge crossing should not significantly impact upon flood levels or flow distribution and therefore has not been the subject of a detailed investigation.

9. References

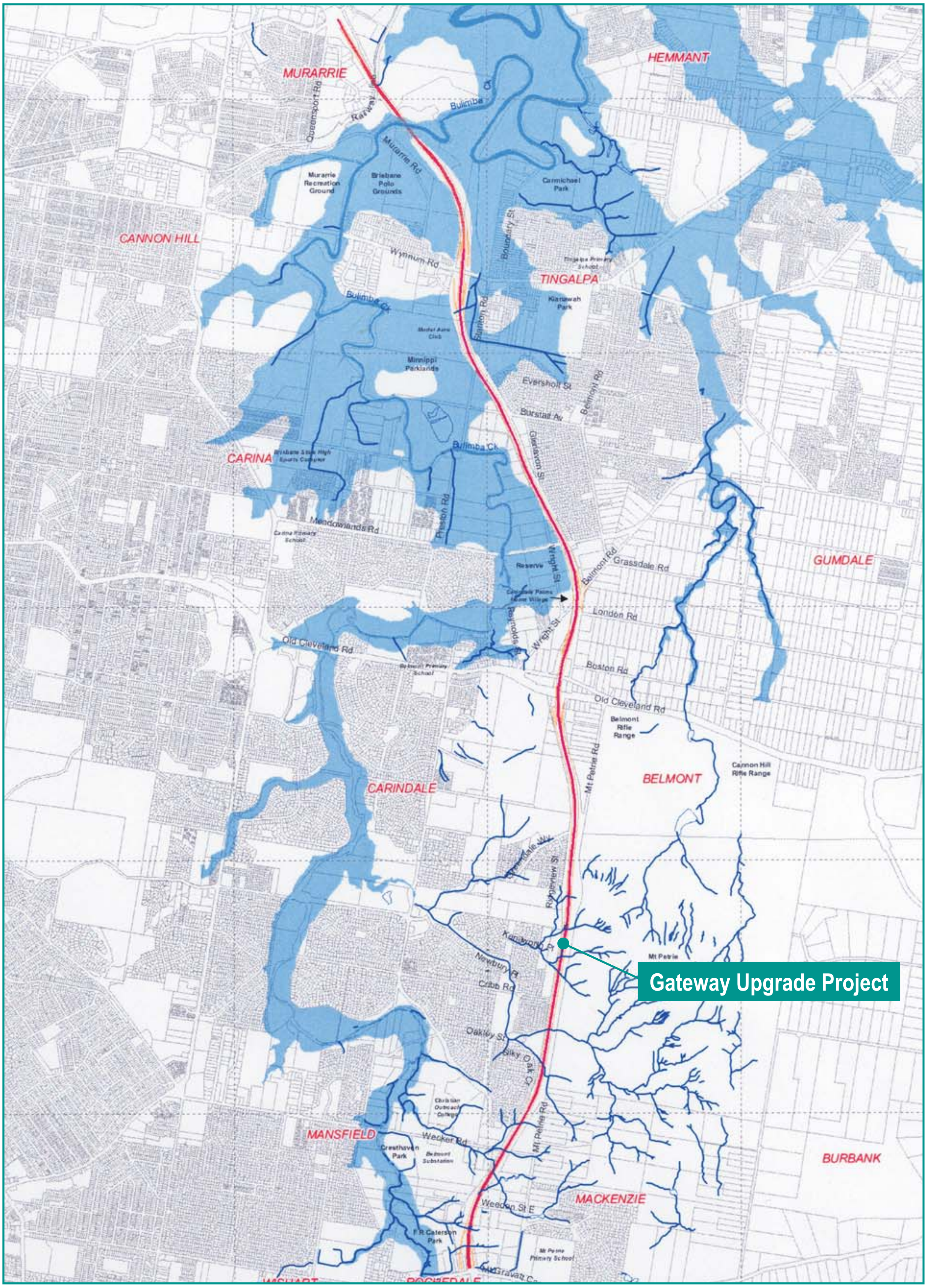
Connell Wagner (1996) *Kedron Brook Flood Study* – Prepared for Brisbane City Council.

GHD (2003a) *Gateway Motorway and Second River Crossing Planning Study: Lytton Road to Nudgee Road* (Vol 3).

GHD (2003b) *Gateway Motorway and Second River Crossing Planning Study: Mt Gravatt – Capalaba Road to Lytton Road* (Vol 5).

Queensland Government (2004) *Gateway Upgrade Project: Draft Terms of Reference for an Environmental Impact Statement* (Unpublished document).

Figures



Source: GHD 2003

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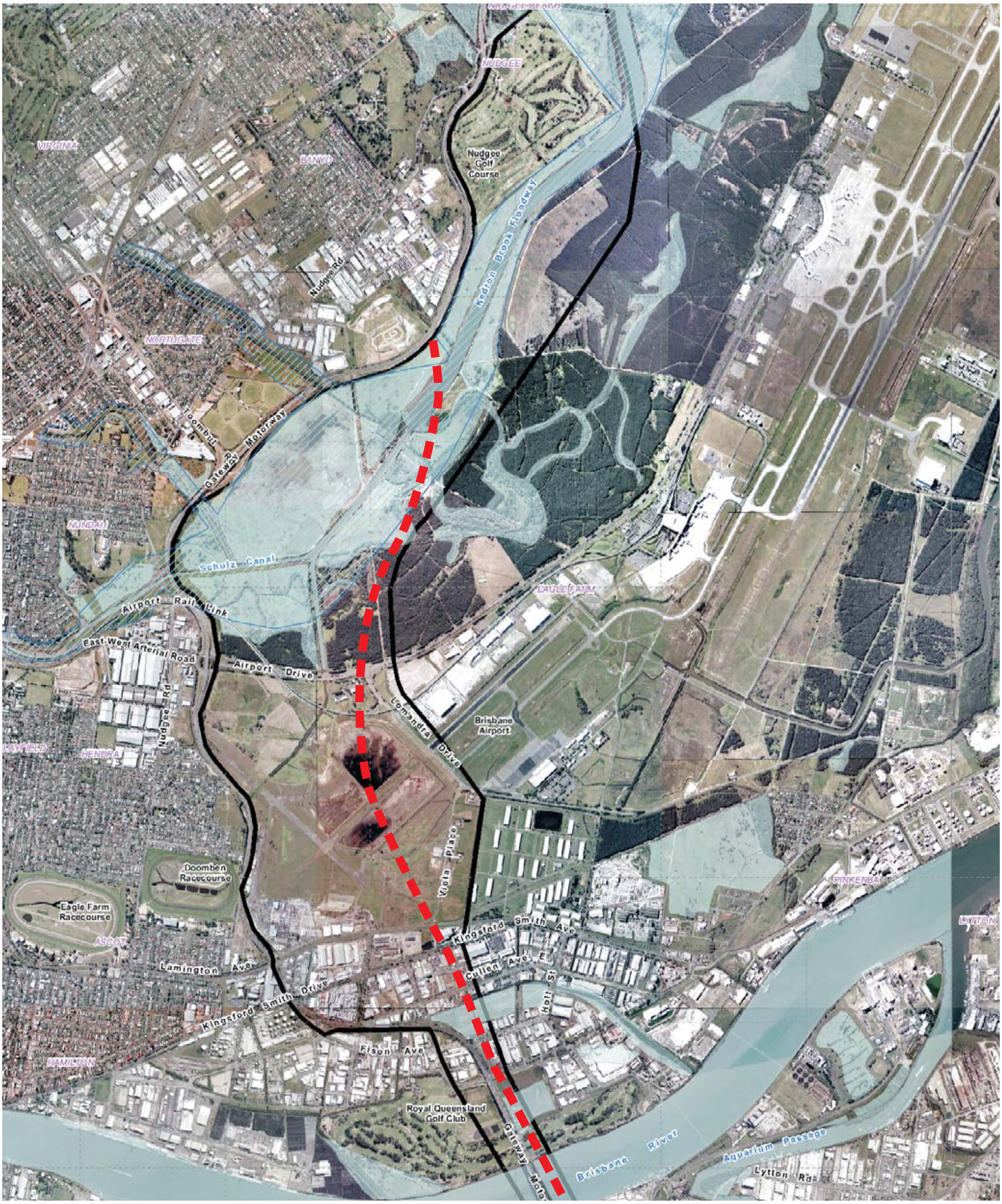
FIGURE 1
Bulimba Creek and Surrounding Environment



Source: GHD 2003

KEY

- Waterways
- Waterway Corridor defined by FRLs
- GUP Corridor

Figure 2
Kedron Brook and Surrounding Environment

Figure 3: Bulimba Creek Model Extent

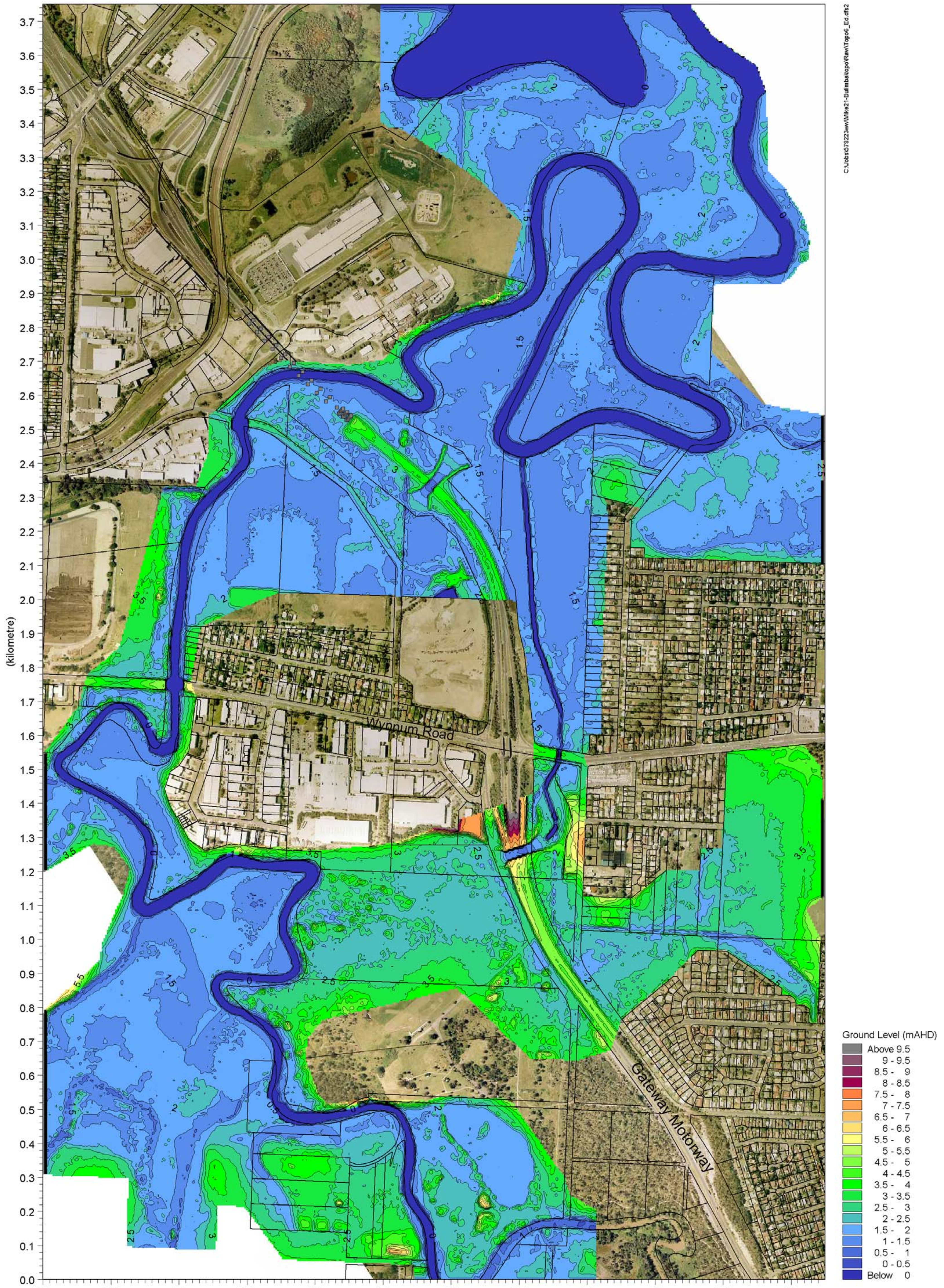


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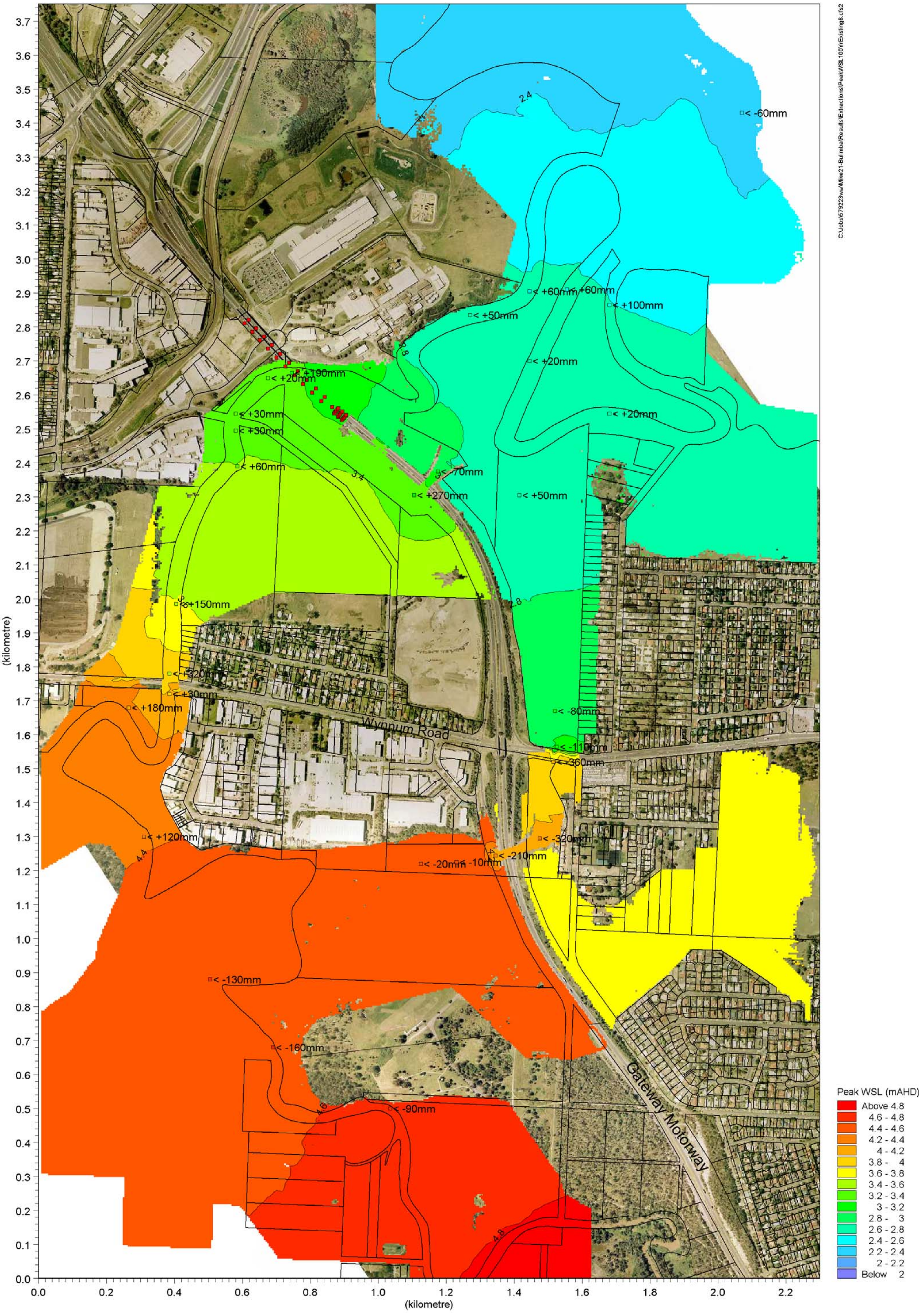
Figure 4 - Bulimba Creek MIKE 21 Model Calibration Results (MIKE 21 - MIKE 11)



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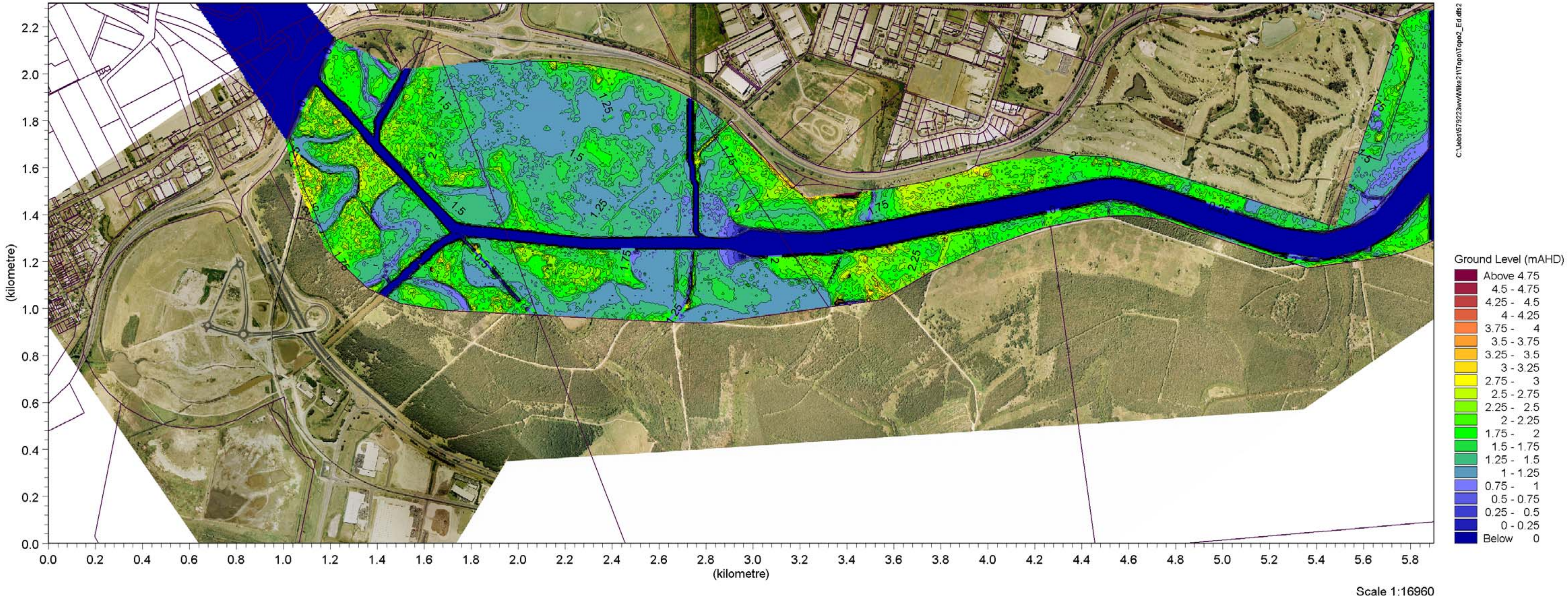


Figure 5 - Kedron Brook Model Extent

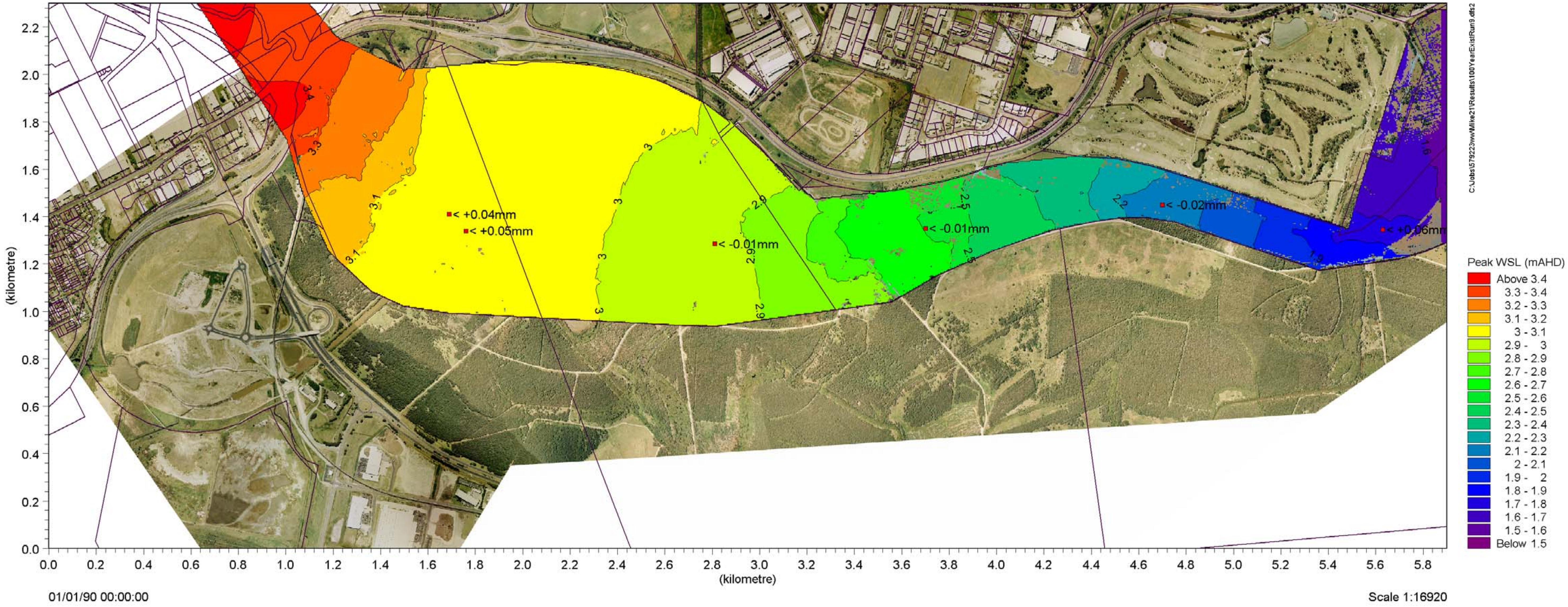
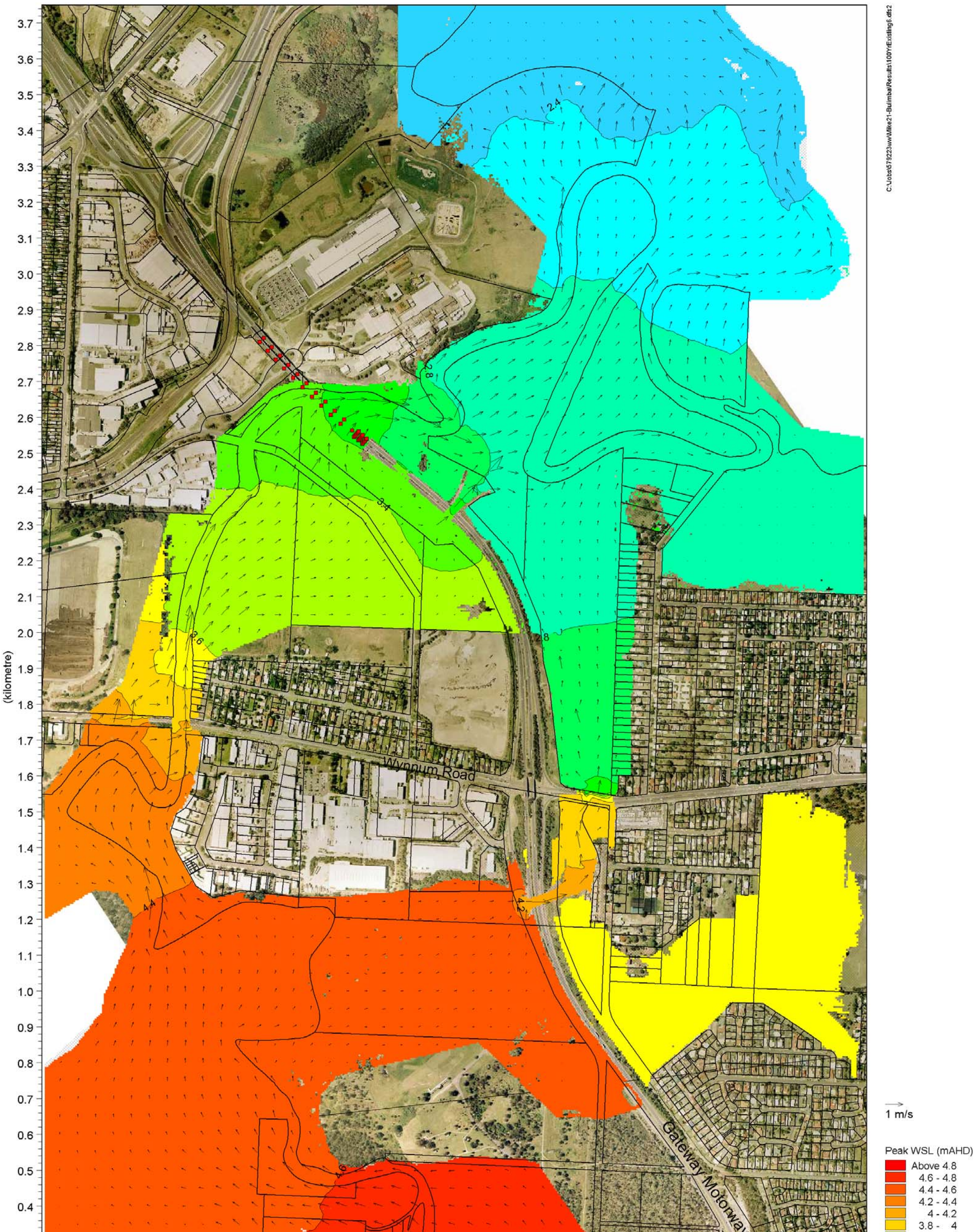


Figure 6 - Kedron Brook MIKE 21 Model Calibration Results (MIKE 21 - MIKE 11)

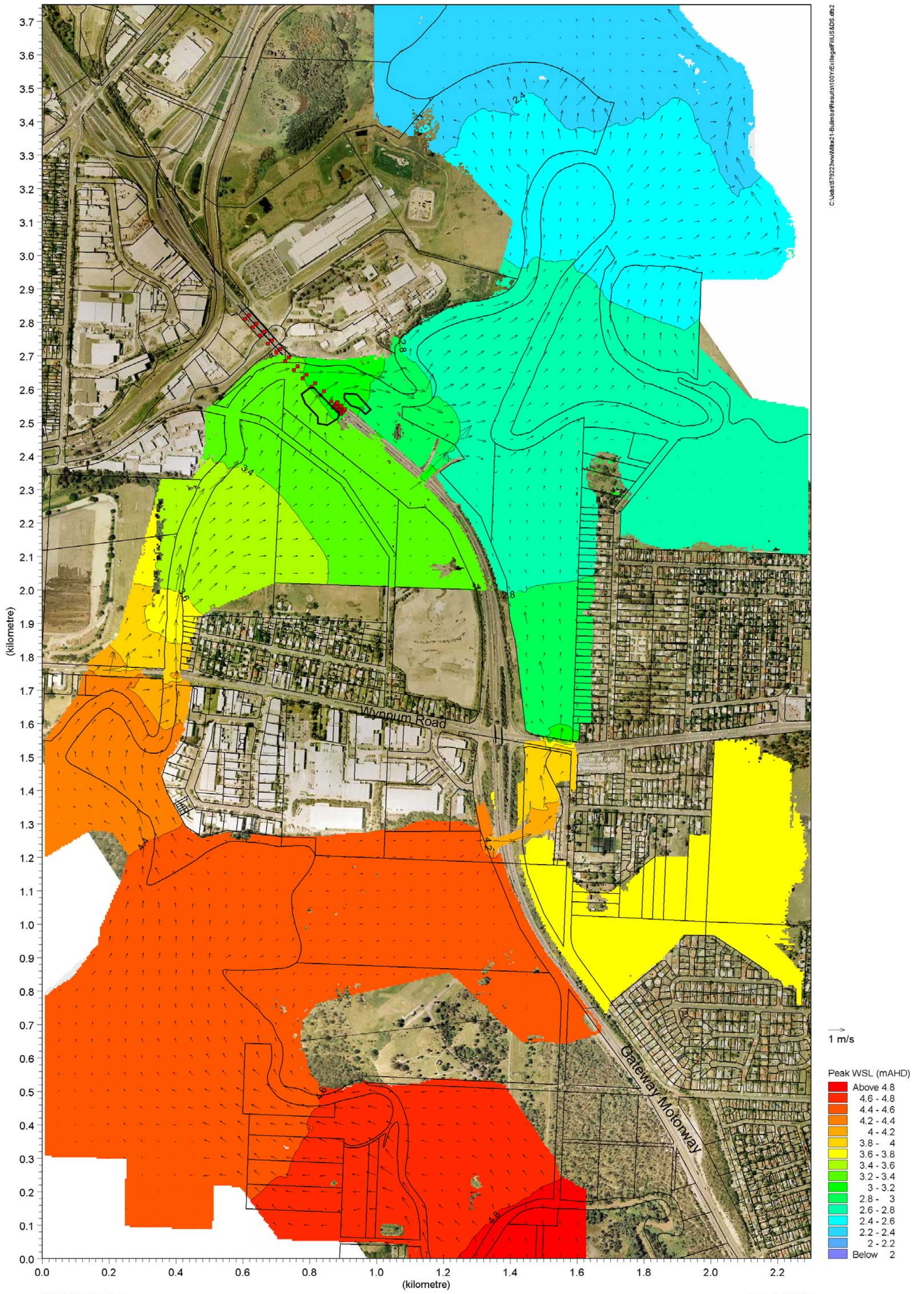
Figure 7a - Bulimba Creek Base Case 100 year ARI Peak Water Levels



01/03/90 14:00:00

Scale 1:10110

Figure 7b - Bulimba Creek Alternate Base Case 100 year ARI Peak Water Levels



01/03/90 22:00:00

Scale 1:10110

Figure 8a - Bulimba Creek Base Case 100 year ARI Peak Depths

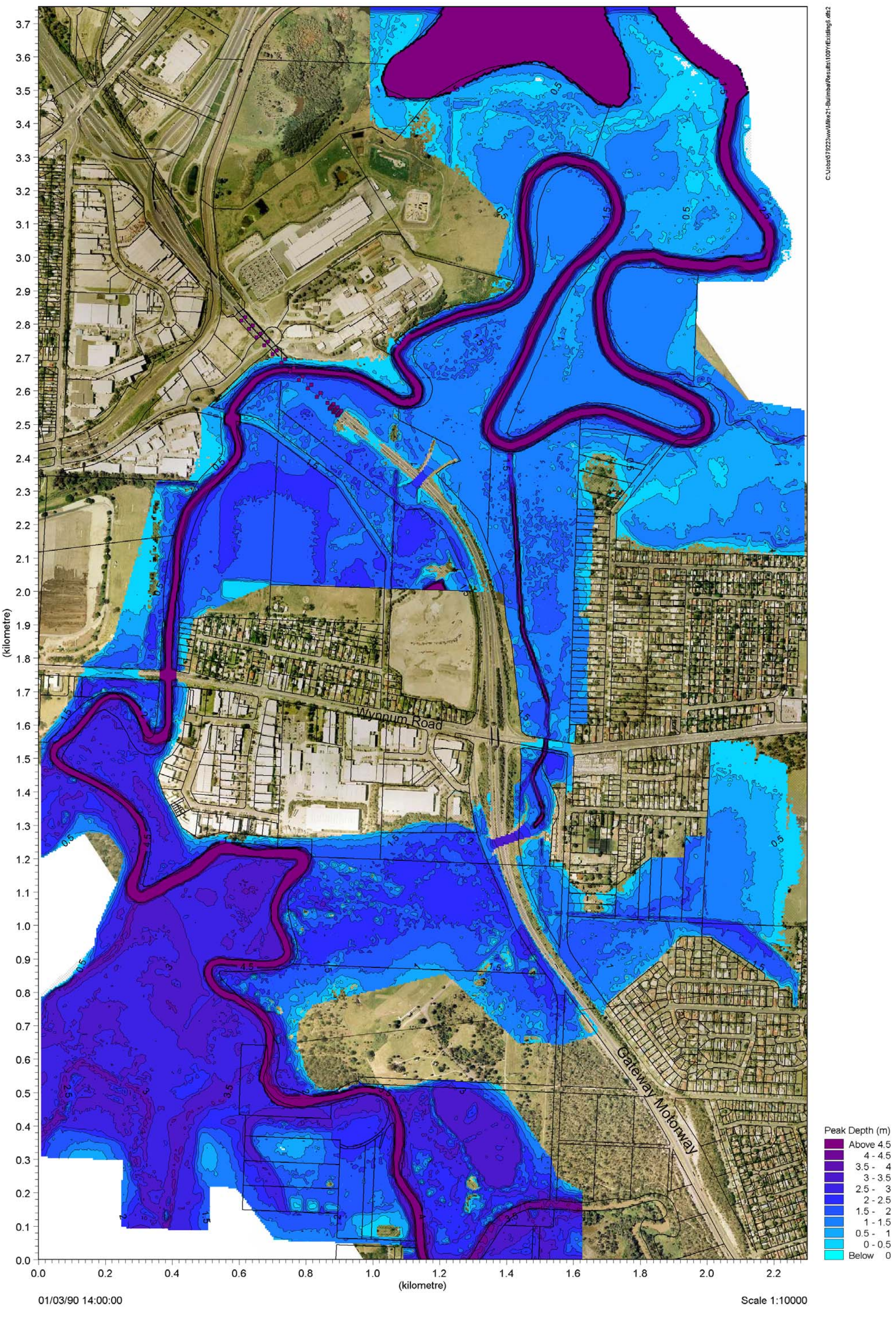


Figure 8b - Bulimba Creek Alternate Base Case 100 year ARI Peak Depths

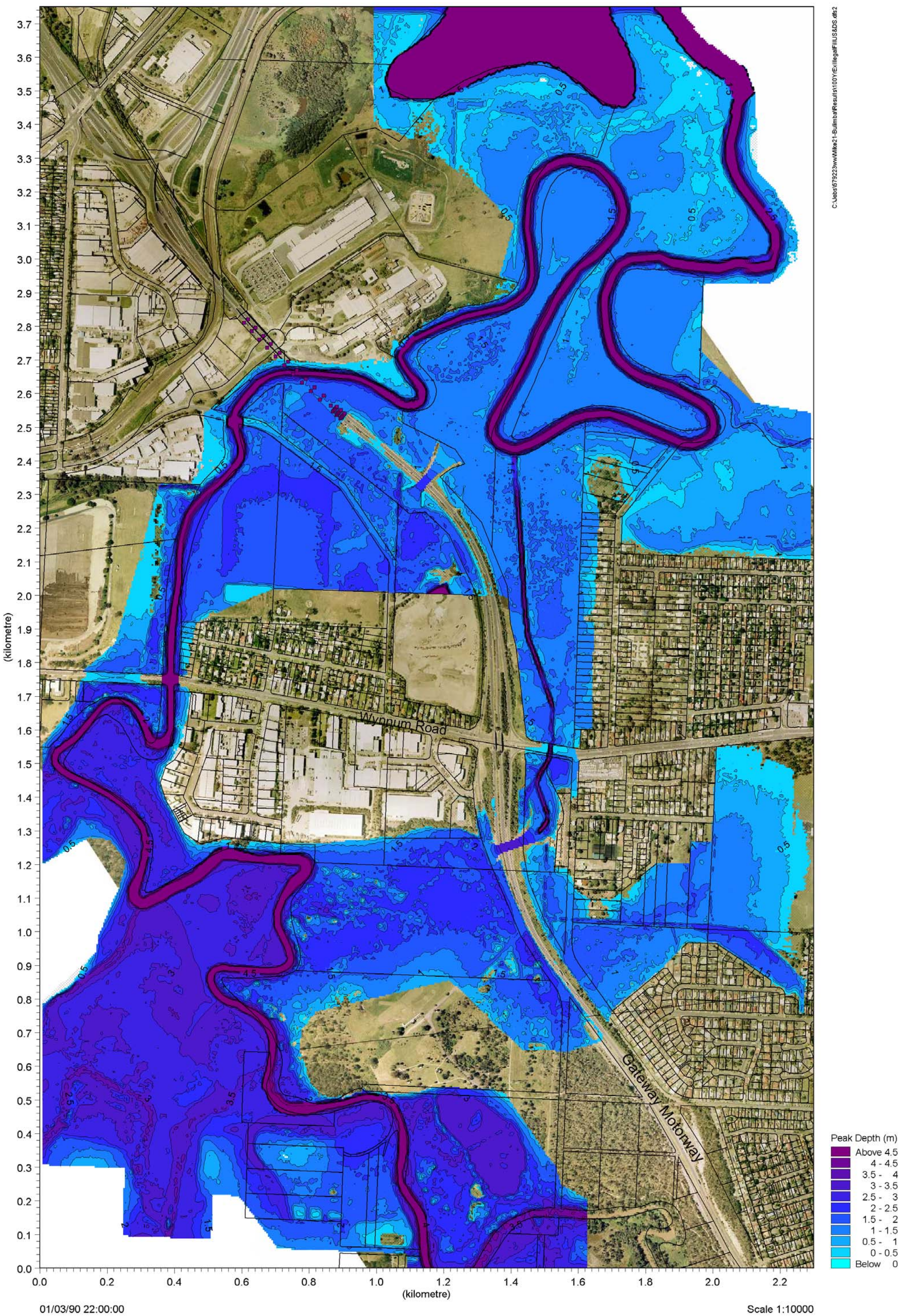
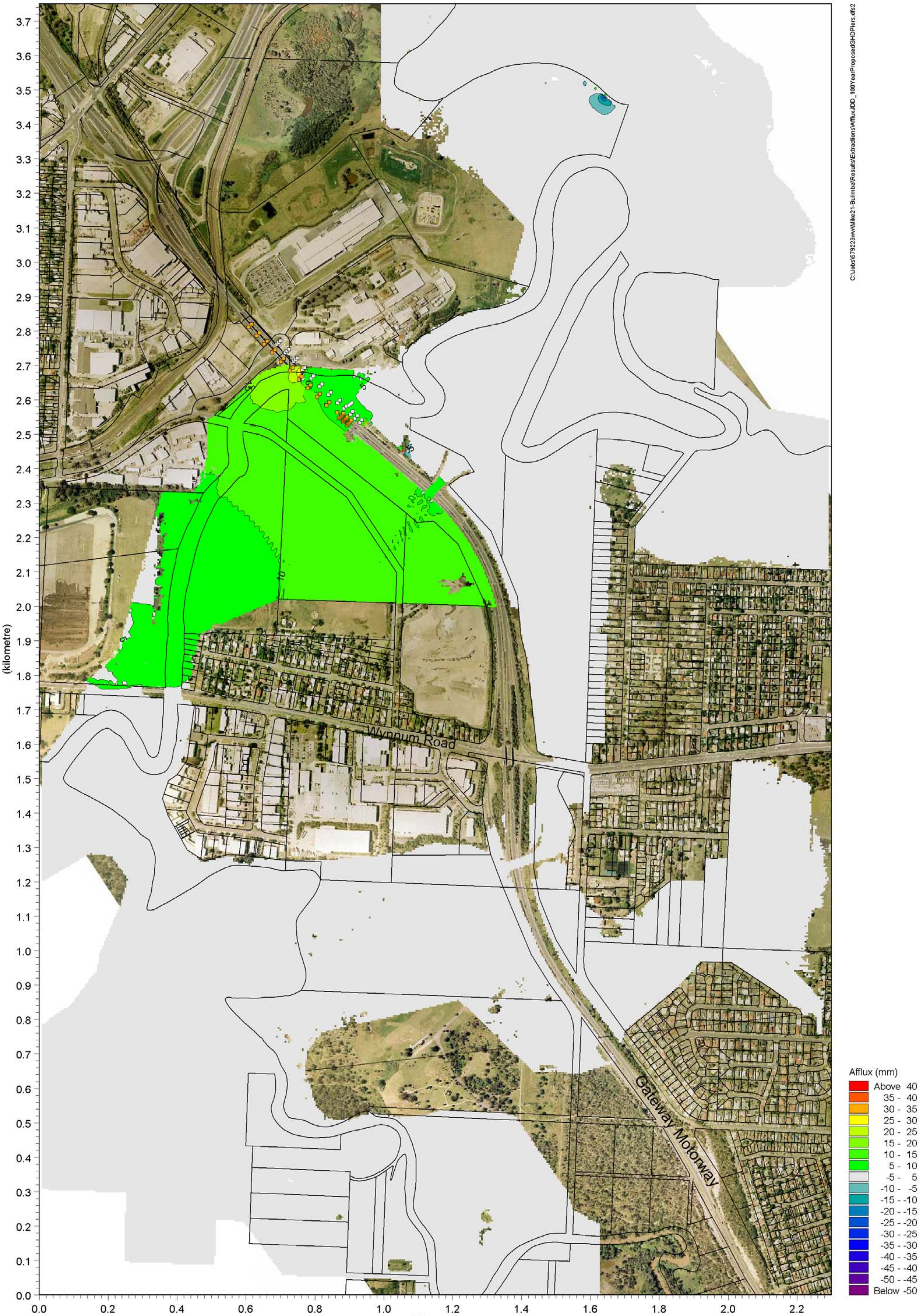
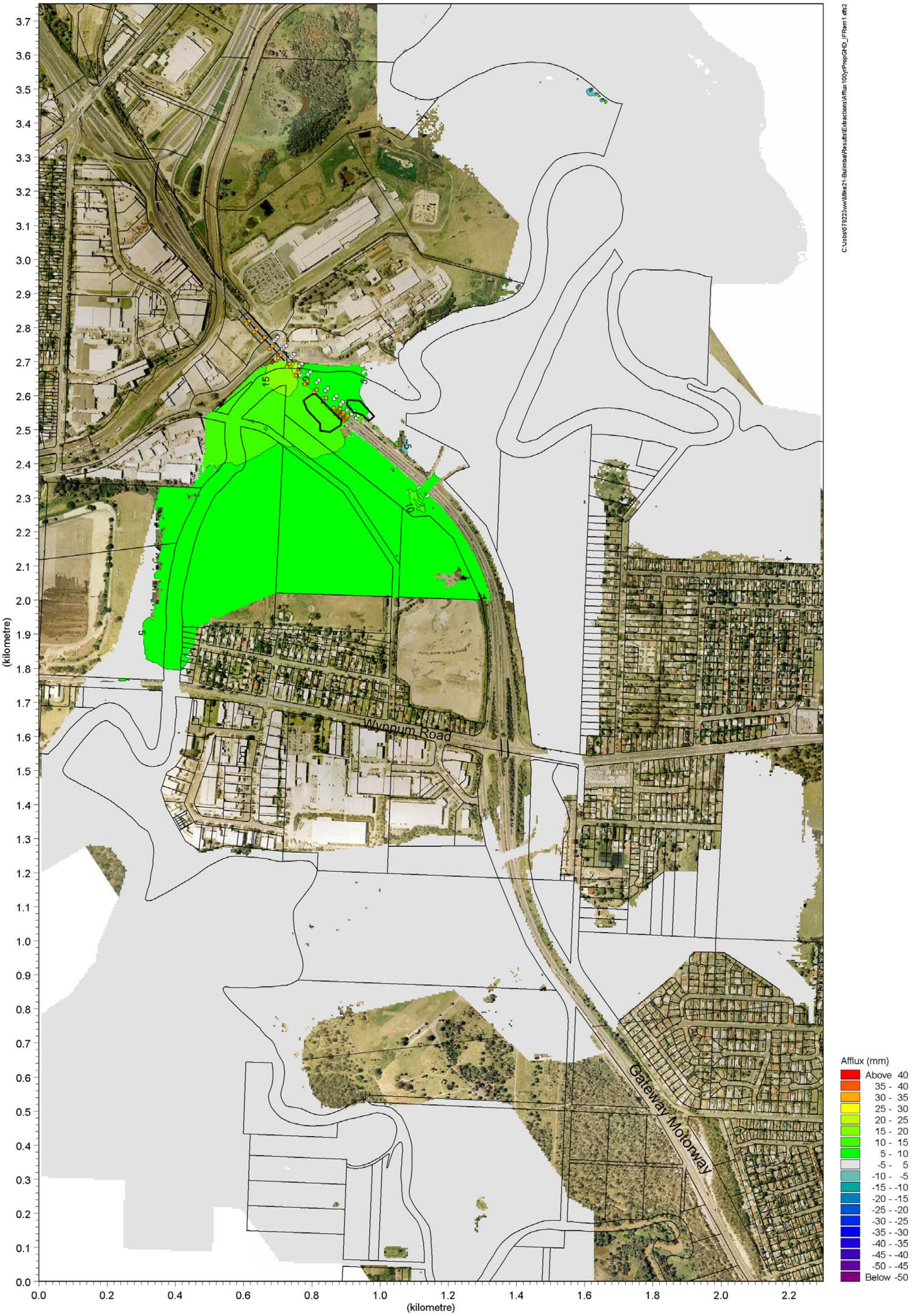


Figure 9a - Bulimba Creek Impact of GUP Works (Developed Case vs Base Case)



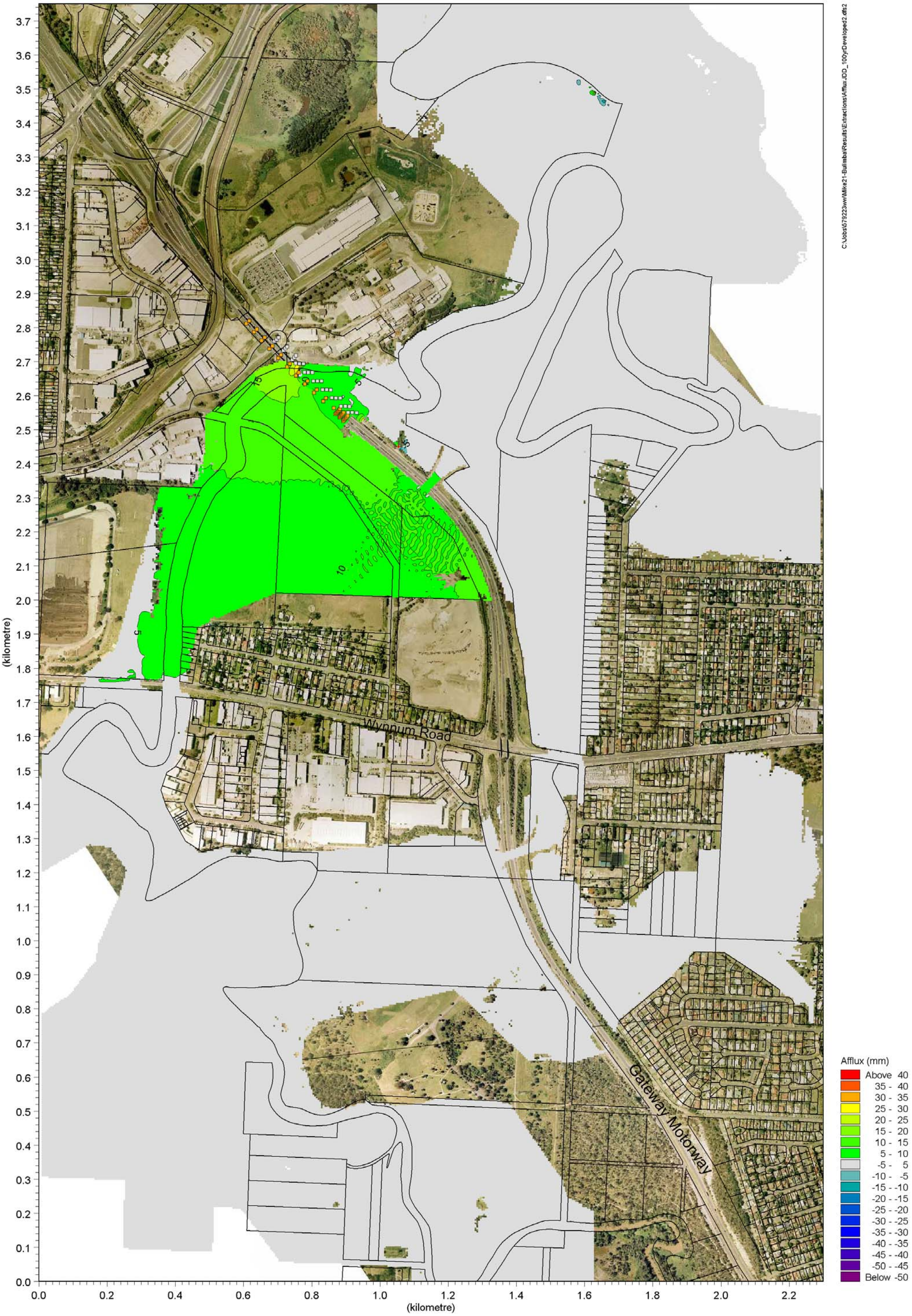
Scale 1:10000

Figure 9b - Bulimba Creek Impact of GUP Works (Developed Case vs Alternate Base Case)



Scale 1:10000

Figure 10a - Bulimba Creek Mitigation Option 1 Results (vs Base Case)



Scale 1:10000

Figure 10b - Bulimba Creek Mitigation Option 1 Results (vs Alternate Base Case)

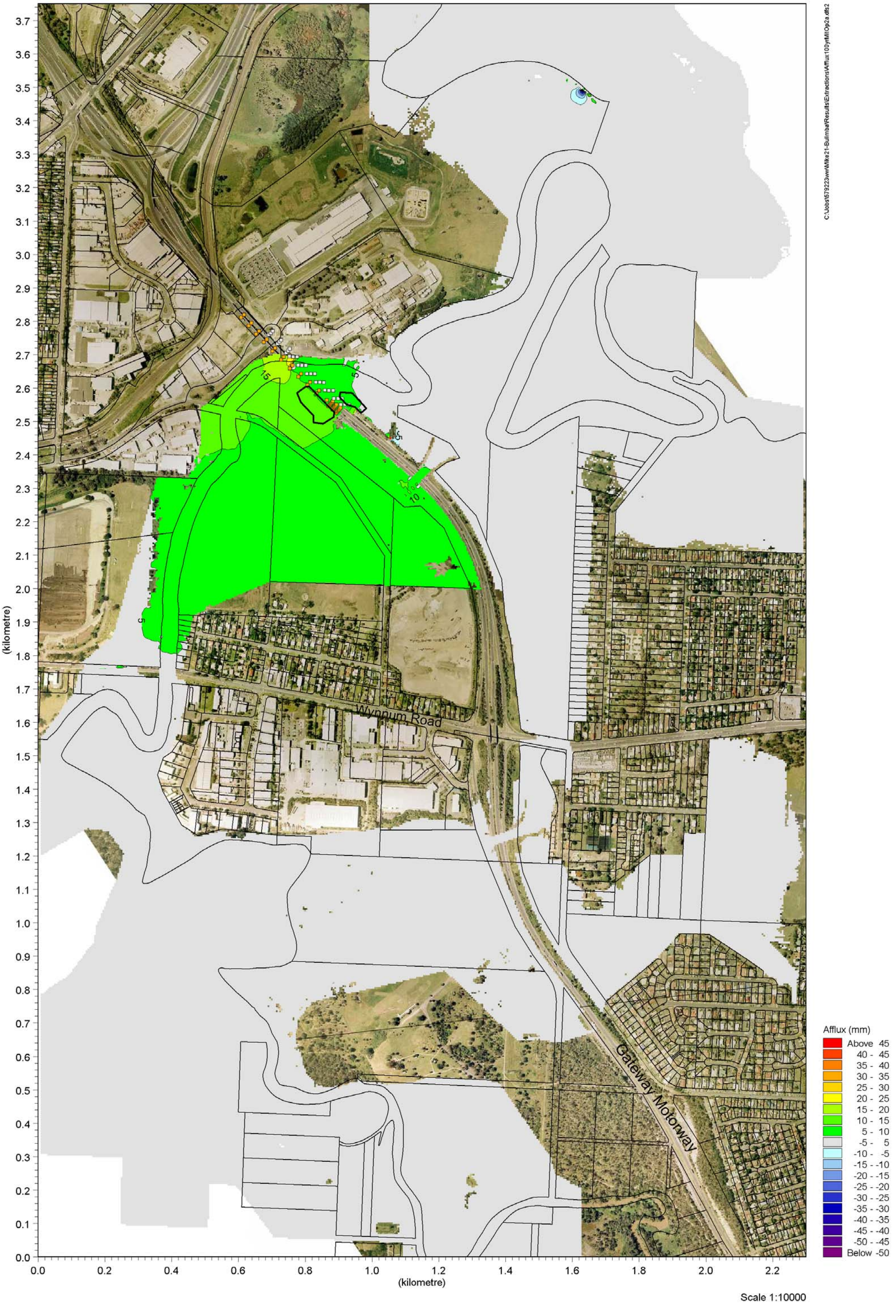
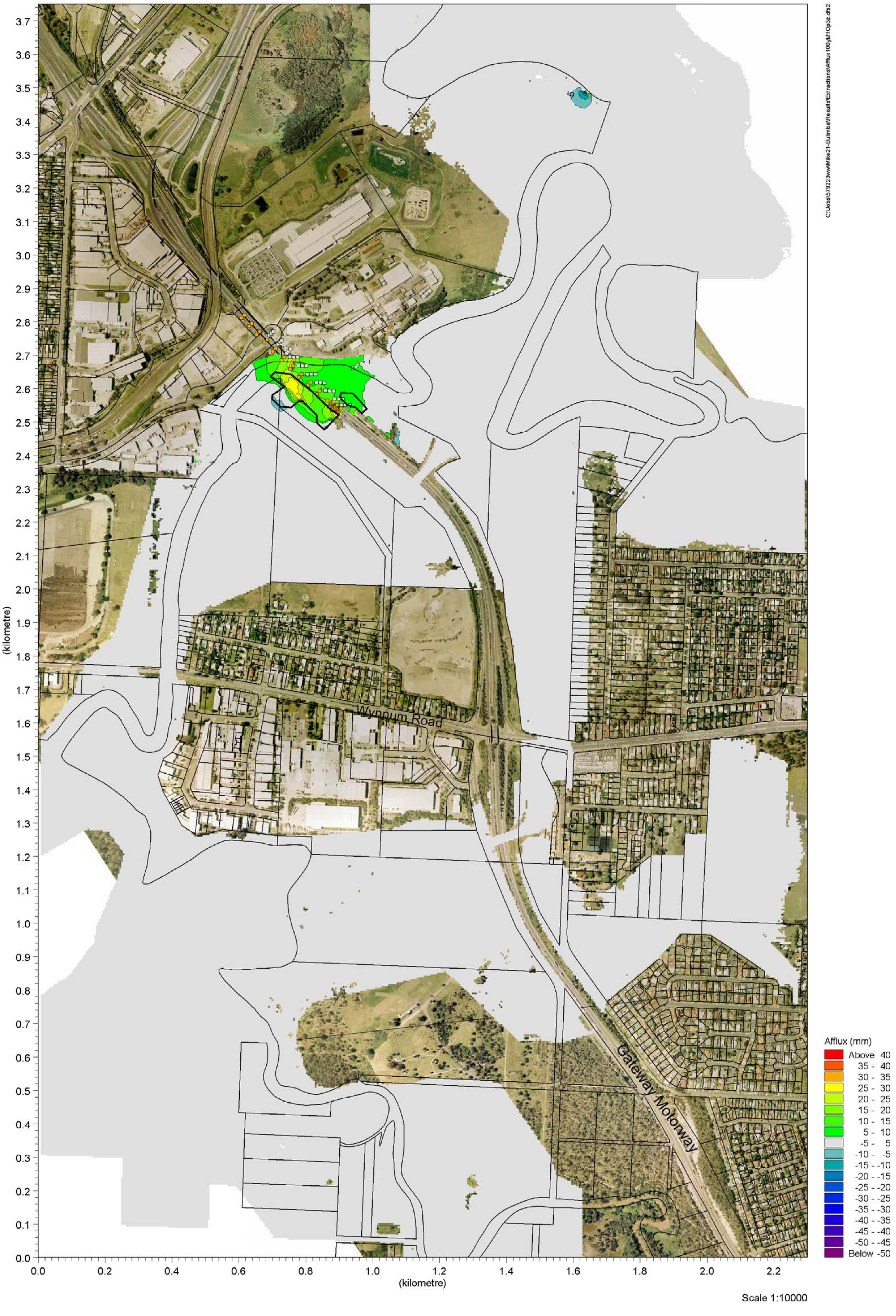


Figure 11 - Bulimba Creek Mitigation Option 2 Results (vs Alternate Base Case)



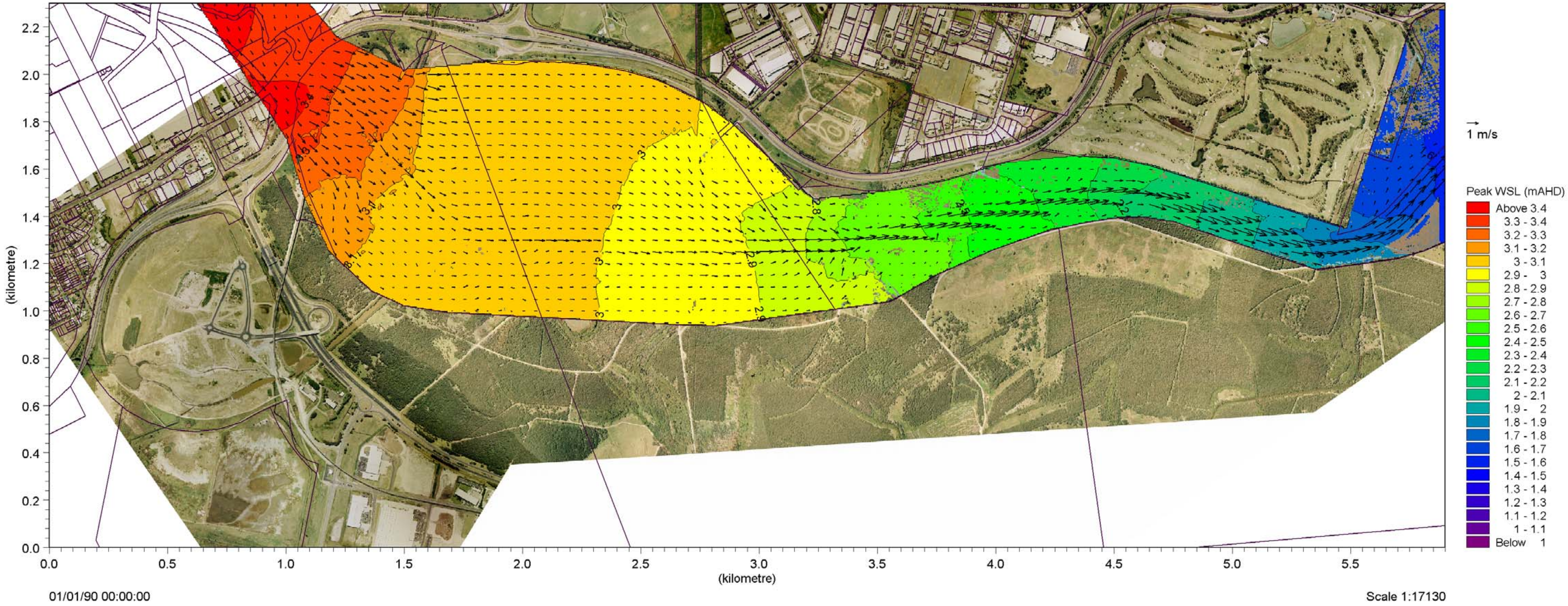


Figure 12 - Kedron Brook Base Case 100 year ARI Peak Water Levels

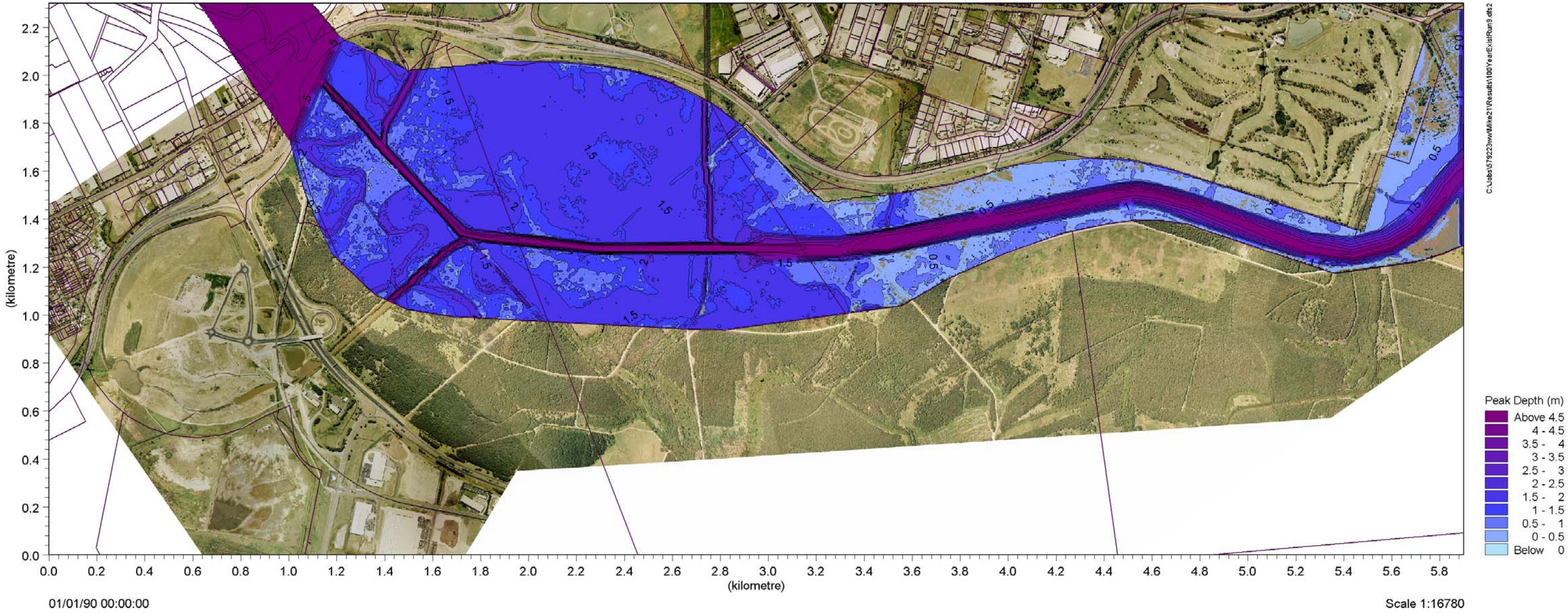


Figure 13 - Kedron Brook Base Case 100 year ARI Peak Depths

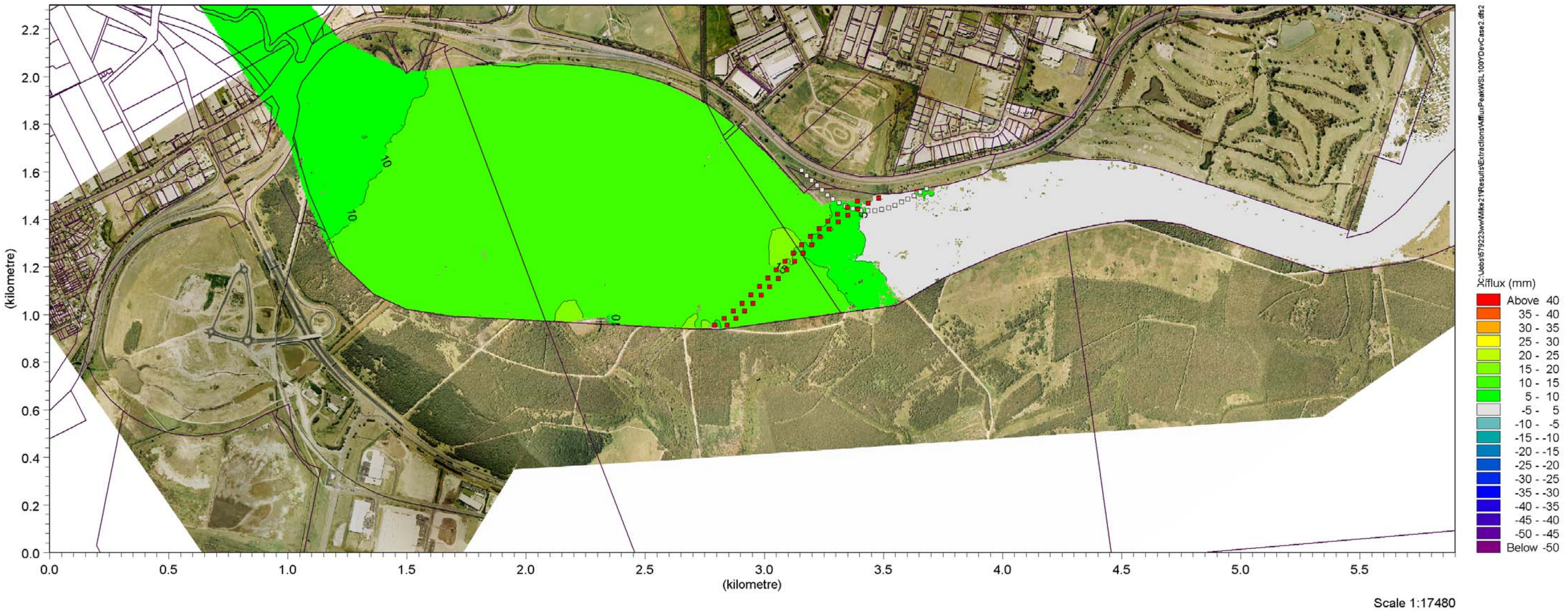


Figure 14 - Kedron Brook Impact of GUP Works (Developed Case)

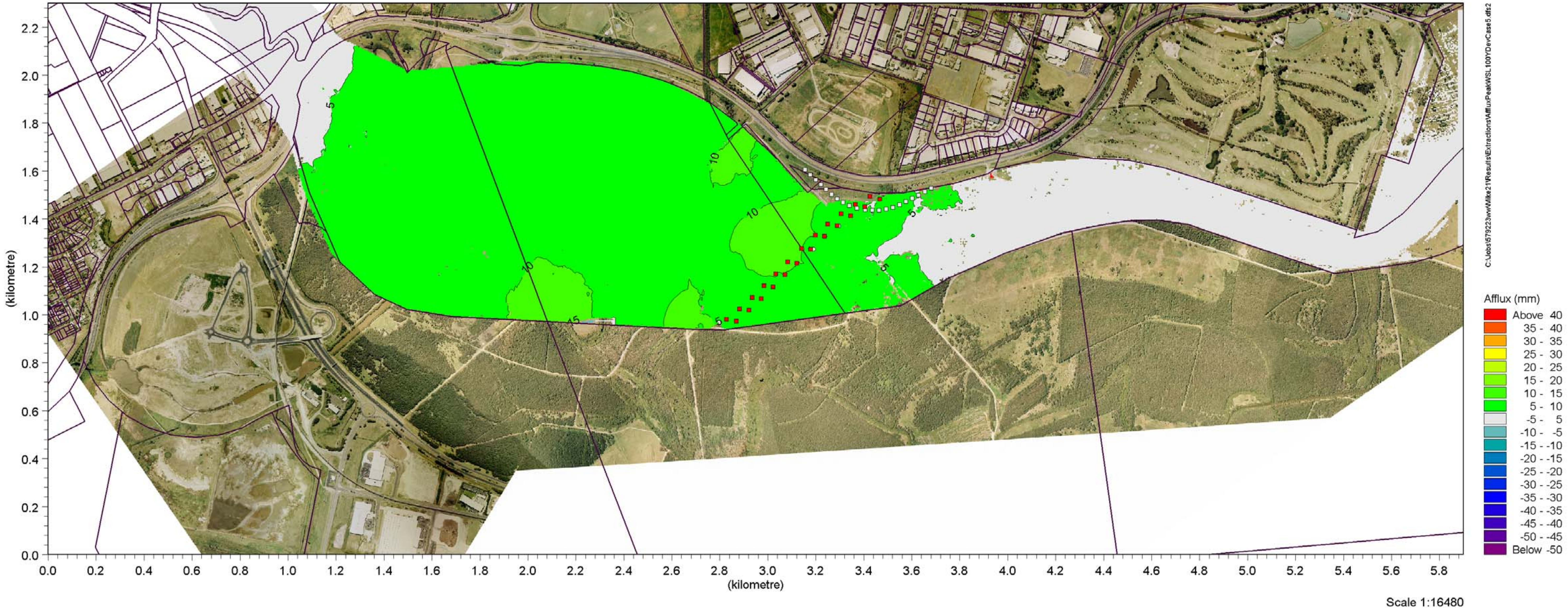


Figure 15 - Kedron Brook Mitigation Option 1 Results

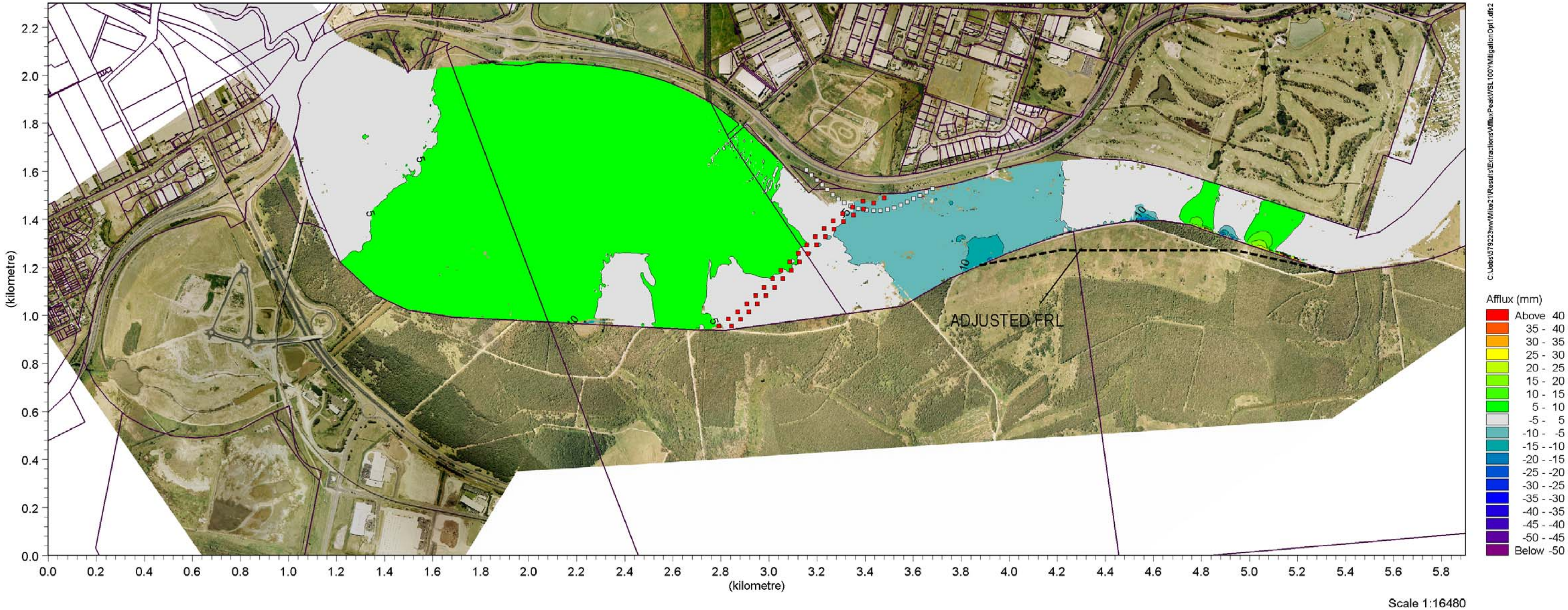


Figure 16 - Kedron Brook Mitigation Option 2 Results

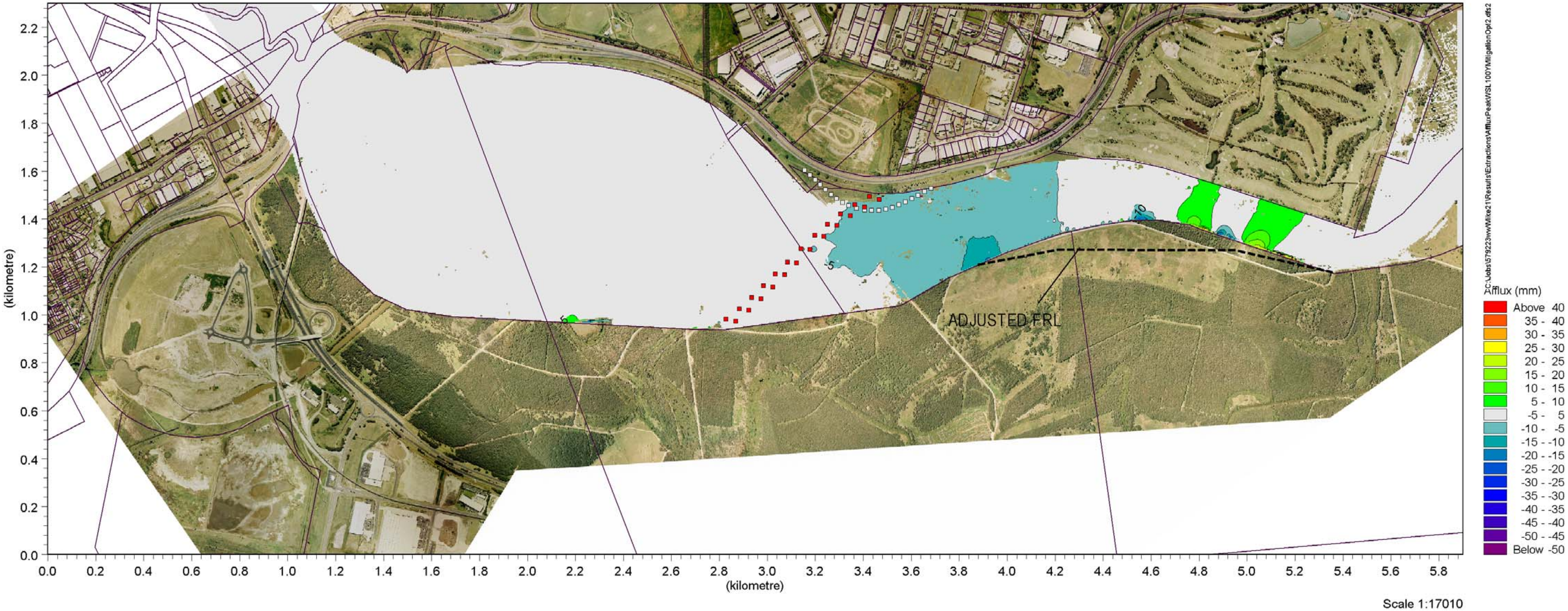


Figure 17 - Kedron Brook Mitigation Option 3 Results

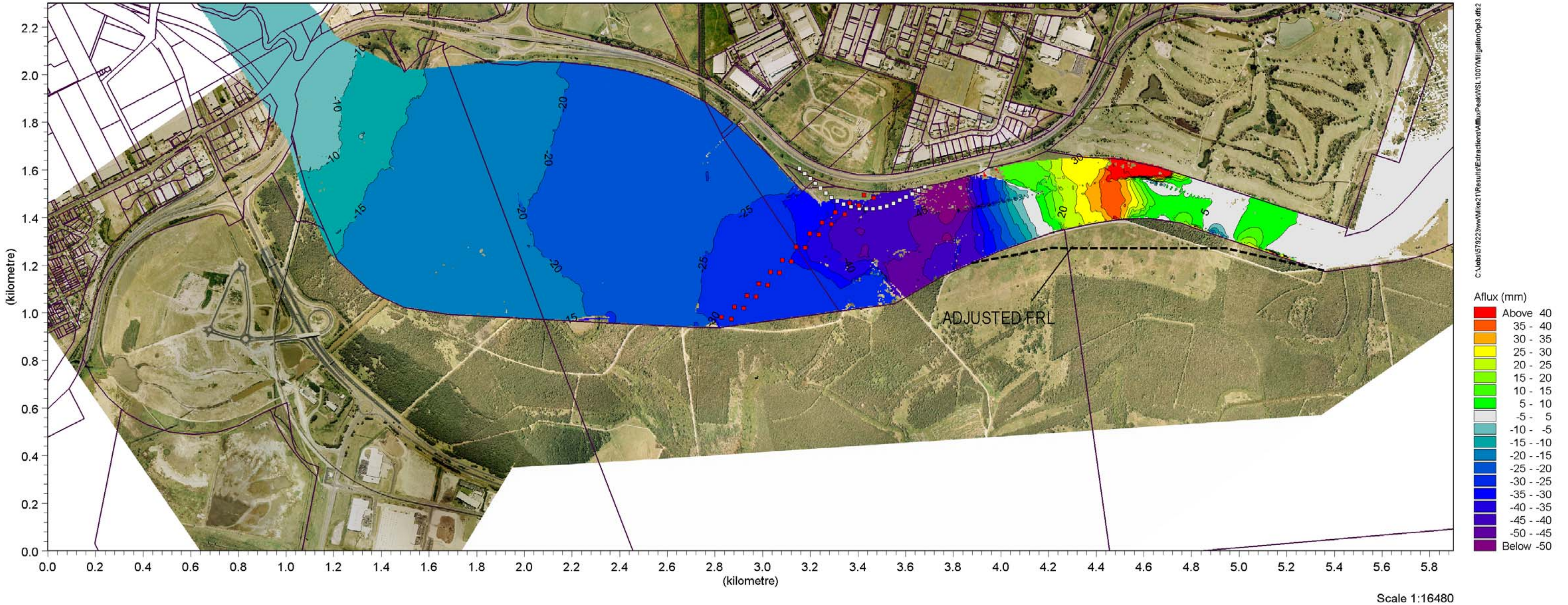


Figure 18 - Kedron Brook Mitigation Option 4 Results

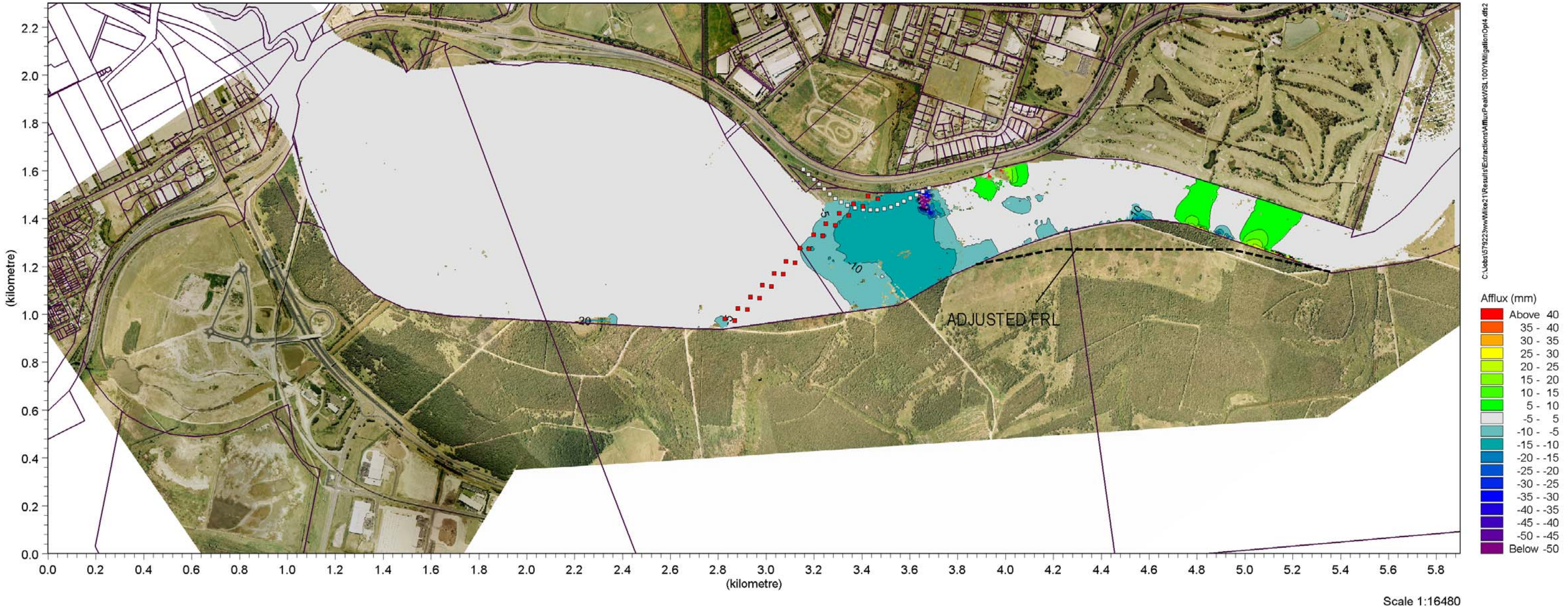


Figure 19 - Kedron Brook Mitigation Option 5 Results

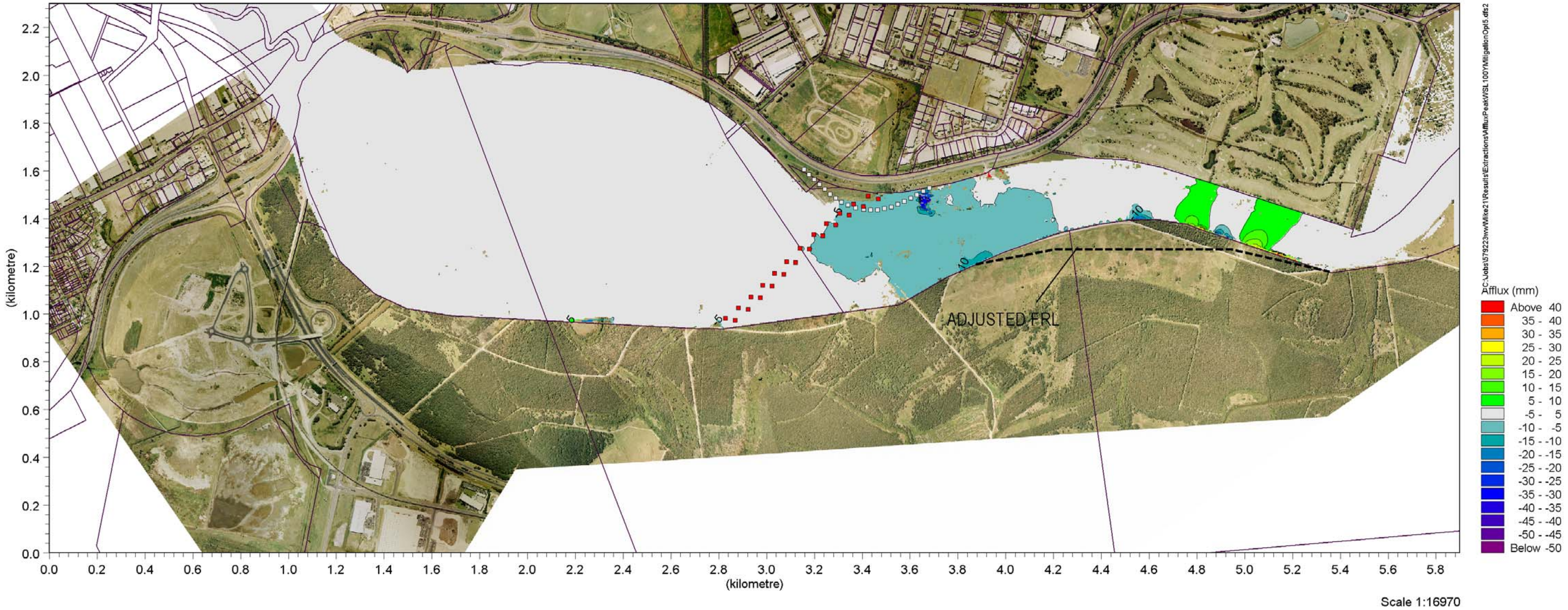


Figure 20 - Kedron Brook Mitigation Option 6 Results

Figure 21 - Kedron Brook Mitigation Option 7 Results

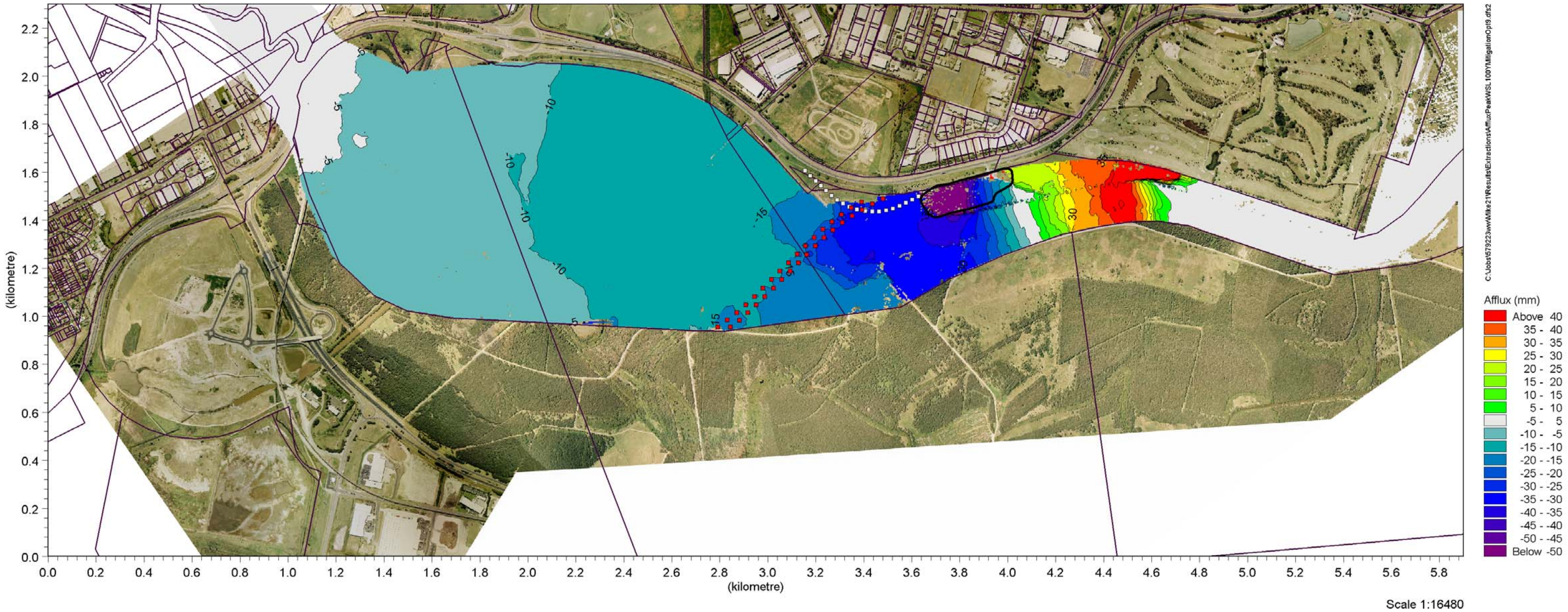


Figure 22 - Kedron Brook Mitigation Option 8 Results

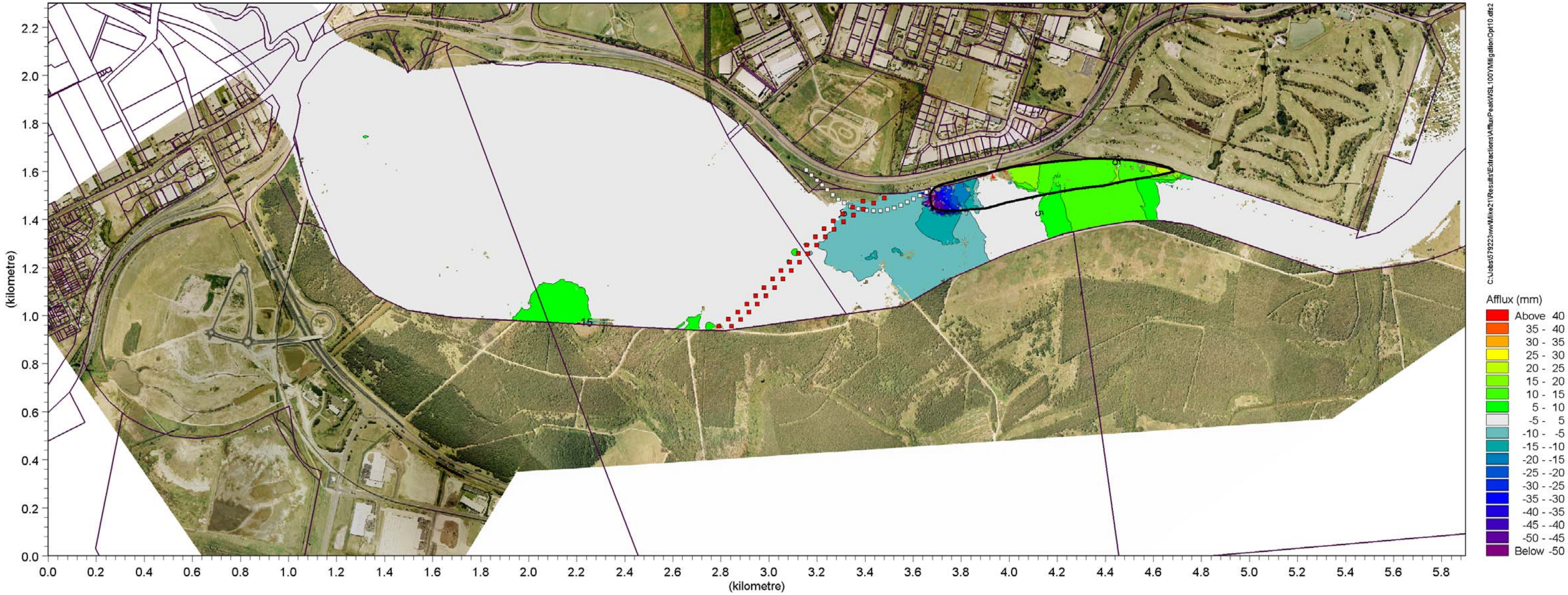


Figure 23 - Kedron Brook Mitigation Option 9 Results

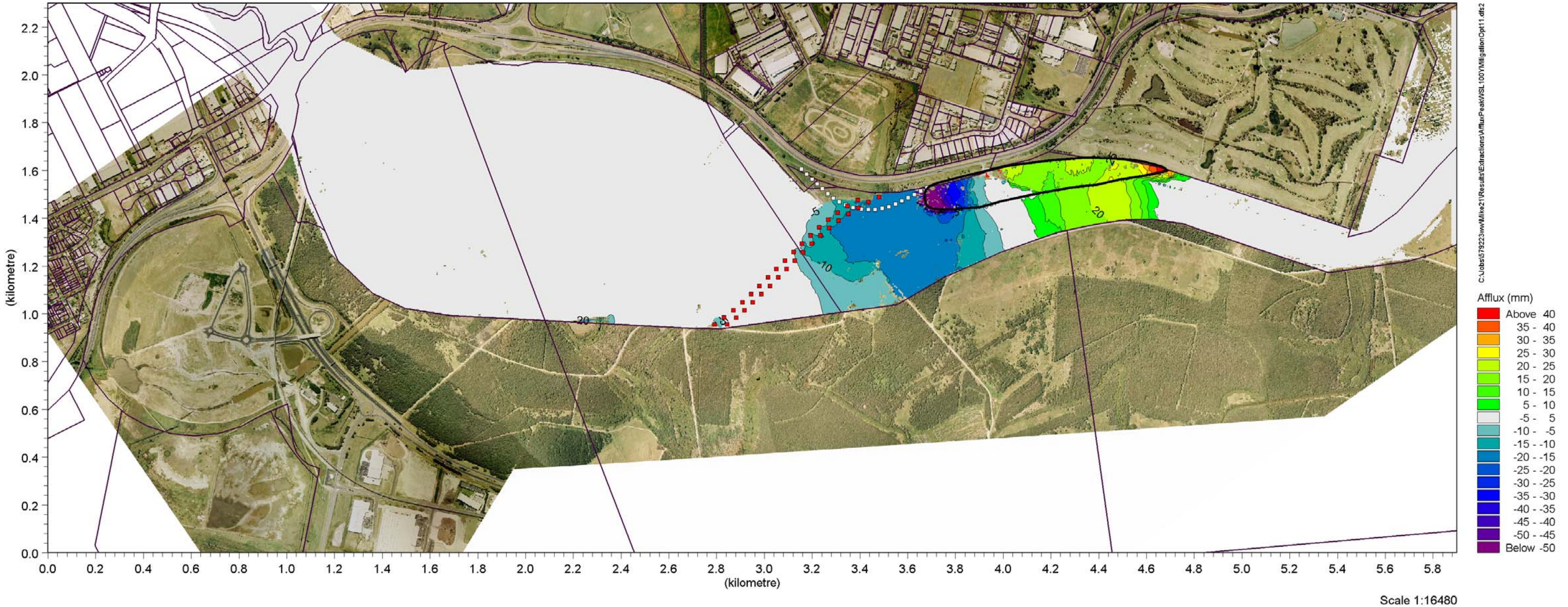


Figure 24 - Kedron Brook Mitigation Option 10 Results

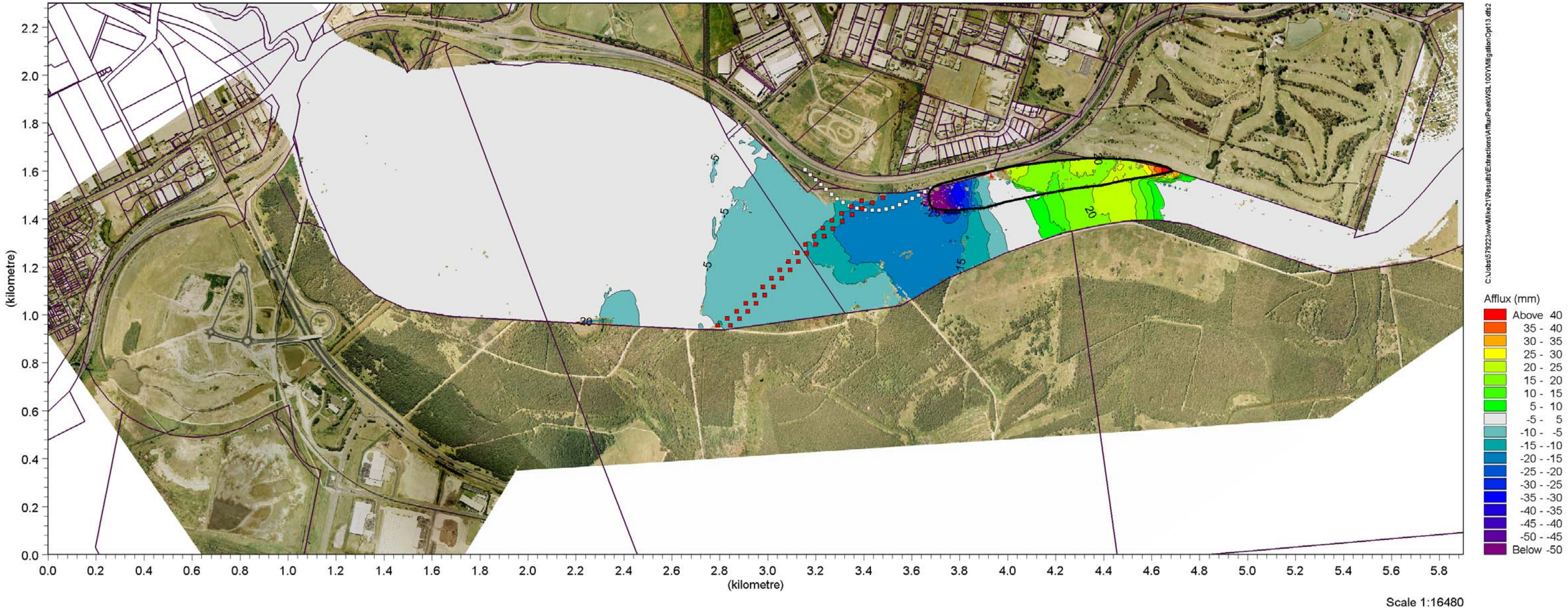


Figure 25 - Kedron Brook Mitigation Option 11 Results