Report

Hoxton Park Airport - Flooding Investigations

15 APRIL 2010

Prepared for

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Executive Summary

Background

URS was engaged by ADW Johnson (on behalf of Mirvac) to provide advice on potential flooding impacts due to the proposed development of the previous site of Hoxton Park Airport. The development consists of 2 large warehouses with an access road from Cowpasture Road, some 250m from the M7 Interchange with Cowpasture Road.

The proposed development requires considerable fill to allow floor levels to be free from flooding for the 1 in 500 year Average Recurrence Interval (ARI) flood – it is understood that this is a condition applying to users of the warehouse. The access road is to be constructed at and above the 1 in 100 year ARI flood and will intrude into areas previously identified as an area within the then airport's operational boundary previously identified for flood passage.

Previous studies by URS had revealed that flood levels were sensitive to the extent of fill on the Hoxton Park Airport site. The sensitivity of flood levels is enhanced by the proximity of residential development east of Cowpasture Road and the recent upgrade of Cowpasture Road by the RTA.

Flood Modelling

The flood scenarios modelled, using the 2D hydraulic model TUFLOW, were based on the 1 in 100 year ARI flood. This model has previously been used for development modelling for both the M7 development, the upgrading of Cowpasture Road and the previous development planning for Hoxton Park Airport.

Two scenarios were developed and modelled to address the passage of flood waters through Cowpasture Road at the South-easterly end of Hoxton Park Airport. These scenarios are:

1. An engineered floodway with a 30 metre entry around the existing service station and flowing to Flood Relief Culvert No. 1, located adjacent to the entry point off Cowpasture Road; and

2. As a consequence of the results of the modelling of Scenario 1, Scenario 2 was developed to assess potential mitigation of those results. Scenario 2 includes the works for Scenario 1 with additional earthworks to upgrade the entry flow regime to Flood Relief Culvert No. 2.

As the road upgrade is essentially complete, the results of the modelling for that condition were adopted as the existing case, against which each scenario is compared to determine impact.

Scenario 1:

Modelling of Scenario 1 showed increases in flood level of greater than 0.15m within the approaches to both Flood Relief Culverts as well as in areas adjacent to the proposed access roadway and the area of the northern floodway. All these increases occur within the Environmental Zone within the previous airport boundary (Hinchinbrook Creek) and in a limited area east of the creek. No existing development is affected by these increases in flood level.

There are also areas of the floodplain where the flood level increases between 0.05m and 0.15m. These increases are generally in the immediate vicinity of the new Cowpasture Road bridge and in the area upstream of the existing, if undeveloped, bus depot[1]. Some increase in levels is identified in a small tributary that flows in the open space between Ward Place and Cowpasture Road. These

[1] It is understood that plans are in place to develop the bus depot site and its flood management requirements will be addressed under the design development for the proposed northern access bridge. This location remains subject to on-going investigation and modelling.

increases effectively stop at an existing drop structure in that tributary and do not threaten flooding of any properties in Ward Place. Generally, floor levels of those properties are 0.5m or more above the 1 in 100 year ARI flood level.

Flow velocity changes generally reflect the changes described above, with the majority of changes in the 0.1m/s to 0.5 m/s. The only locations where velocity increases by more than 0.5 m/s are in the immediate vicinity of the entrance flowpaths to Culvert 1.

Flood Hazard, based on depth/velocity criteria, shows no significant change to the existing conditions, with only those areas with the greater than 0.15m depth change having some small areas change from low to high hazard. This can mostly be ascribed to changes in depth.

The flood depth changes under Scenario 1 are shown on Figure 1[*]. Velocity Changes are shown on Figure 2 and Flood Hazard changes on Figure 3.

Scenario 2:

Modelling of Scenario 2 in comparison to the existing situation showed almost identical results to Scenario 1 and any changes from Scenario 1 to Scenario 2 are very localised. While the additional works did improve the flow regime in the culvert area, there is no significant change to flood depth impacts indicated under Scenario 1 throughout the area being modelled.

Scenario 2 also had similar results to Scenario 1 for Flow Velocity and Flood Hazard.

The flood depth changes under Scenario 1 are shown on Figure 4. Velocity Changes are shown on Figure 5 and Flood Hazard changes on Figure 6.

Impacts on Cowpasture Road

The design standard for the upgrade of Cowpasture Road called for flood immunity to the 1 in 20 year ARI flood and was designed to be overtopped at both Flood Relief Culverts. Under existing conditions, the overtopping in a 1 in 100 year ARI flood occurs over slightly more than 1 hour. The overtopping of Cowpasture Road occurs, as designed, to the section of road over the two flood relief culverts and does not affect the intersection of Cowpasture Road and the planned access road.

Both Scenario 1 and Scenario 2 improve the flooding situation to some degree as overall flood levels and flow velocities across Cowpasture Road are reduced, though the time of overtopping remains consistent with the existing situation. There is a small increase in velocity across the road (0.1 – 0.5 m/s) in the area between the Culvert and the western side of the service station however such increases are within the design tolerances. The velocity changes within the structures themselves are all within the design tolerances for the upgrade and the designed erosion control works will be adequate for that purpose.

The changes proposed will not have any adverse impact on the operation and maintenance of Cowpasture Road.

[*] It should be noted that the significant depth increase in the south-west corner of the site for both scenarios is the result of that area being used as a retarding basin which is incorporated into the designs for Cowpasture Road.

Liverpool City Council

Impacts on Residential Areas

There is significant residential development east of Cowpasture Road and Liverpool City Council has a range of flood management measures in the area. As indicated previously, some increase in flood levels is identified in a small tributary that flows in the open space between Ward Place and Cowpasture Road. These increases effectively stop at an existing drop structure in that tributary and do not threaten flooding of any properties in Ward Place. Generally, floor levels of those properties are 0.5m or more above the estimated 1 in 100 year ARI flood level and the development scenarios as modelled do not pose any threat of flooding to these properties.

Downstream Impacts

Downstream of Cowpasture Road, under existing conditions, there are no significant changes to flood levels, flow velocity or flood hazard. The changes that are indicated by the model are of minor proportions and are within the range of variations that could be expected under actual flooding conditions.

Findings & Conclusion

Based on the currently proposed development scenarios, flood levels in the 1 in 100 year ARI flood will increase to the greatest degree within the Environmental Zone east of the former airport and in the approaches to the Flood Relief Culverts constructed as part of the Cowpasture Road upgrade. Changes to flow velocity and flood hazard are also confined to these areas. All flood impacts are confined to areas that will not be subject to future development.

The development of the Hoxton Park Airport site as currently proposed could take place under these conditions.

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Introduction

URS was engaged by ADW Johnson (on behalf of Mirvac) to provide advice on potential flooding impacts due to the proposed development of the previous site of Hoxton Park Airport. The hydraulic modelling undertaken as part of this project was undertaken by Golder Associates, who had undertaken previous modelling of the area for URS.

1.1 Site Description

Hoxton Park Airport is situated on the floodplain of Hinchinbrook Creek within the Liverpool City Council (LCC) area. It is approximately 8 kilometres west of Liverpool City Centre. It occupies an area of approximately 82 ha.

The airport site, shown in Figure 1, is bounded on the east by Hinchinbrook Creek, with extensive urban development further east on the eastern side of Cowpasture Road, and the M7 Motorway to the west. Current access to the site is via a limited capacity road off Cowpasture Road that has been altered during the M7 construction.

Hinchinbrook Creek flows north to south between Cowpasture Road and the runway threshold (the cleared area between the runway and the trees along the Creek floodplain). Flooding affects a portion of the site – this is described further in Section 2.

1.2 Report Format

This Report addresses the flood impacts on Hoxton Park Airport and the assessment of the hydraulic impacts of a range of development and fill scenarios at the Airport.

The Report includes the following Sections:

- Existing Flood Conditions;
- The Hydraulic Model;
- Development Options;
- Flood Modelling Results;
- External Impacts; and
- Conclusion.

Existing Flood Conditions

2.1 Existing Flood Conditions

Being located on a relatively large floodplain[2], the airport site can be affected by flooding from Hinchinbrook Creek and/or by flows from three (3) unnamed streams that enter the site from the west. None of the minor streams has a significant geomorphic shape, having been significantly changed by man-made drainage and other constructions. The two "southern" streams have been confined to man-made drainage channels and the Northern stream is currently an overland flow area above a series of culverts (3x1200mm pipes).

Under existing (M7 constructed) conditions, flooding affects various areas of the airport - a significant portion (approximately 15%) of the southern end of the airport site as well as a section of the airport where the northern tributary enters the site.

The southern area has three possible sources of flooding:

- An inflow from the west which then feeds to a defined open drain flowing to Cowpasture Road;
- An inflow from the southwest that has been accommodated by a significant drainage structure under the M7; and
- Flow from Hinchinbrook Creek to the east.

With the exception of the latter, these inflows are accommodated in the M7 by culverts designed to pass 1 in 500 year Average Recurrence Interval (ARI) flood flows without any (zero) afflux (increase in flood level upstream).

The northern area, marked by the existing culverts, has a significant inflow from the west as well as backwater flooding from Hinchinbrook Creek. There is a major bridge structure in the M7 to account for flows from Northern.

2.2 Cabramatta Creek Floodplain Risk Management Study & Plan

The current LCC development plans that cover the Hoxton Park Airport site are the Cabramatta Creek Floodplain Risk Management Study & Plan [Bewsher, October 2004]. The Southern Hoxton Park Aerodrome Release Area Master Plan [LCC, June 2004] addresses land to the west of the M7, an area now known as Middleton Grange.

One detention basin (Basin 6) had originally been proposed within this new release area on the northern creek as part of LCC's detention basin strategy [Kinhill, 1992]. This potential basin was incorporated into both the Floodplain Risk Management Study & Plan and Southern Hoxton Park Aerodrome Release Area Master Plan.

The route of the M7 compromised the construction of a basin at this location, with the road formation effectively taking up most of the storage area, together with the large waterway area required for the bridge constructed to cater not only for water flows but also a potential access road under the M7. The bridge structure and design requirements effectively preclude any basin wall in this area.

A replacement for basin 6 is being addressed as part of development plans for the site. Its design is subject to a separate report from other consultants.

[2] The floodplain of any stream is defined as the area affected by the Probable Maximum Flood (PMF) – Floodplain Development Manual (NSW Government, 2005)

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The Hydraulic Model

3.1 Background

The hydraulic modelling undertaken in this assessment is based on a 2-dimensional TUFLOW model. The model was originally formatted by WBM Oceanics as part of the investigation of flooding in the Cabramatta Creek catchment and modified by SMEC for better resolution in the areas near Cowpasture Road and assessing the impacts of the M7 (Western Sydney Orbital).

URS used the SMEC model for its assessments of development scenarios covered in a report to HPAL Freehold Pty Ltd in September 2006[3]. This model was further developed to assess flooding implications of the upgrade of Cowpasture Road by the Roads and Traffic Authority (RTA). With the approval of the RTA, this latest model was used in the assessment of the current development proposal.

3.2 The Original TUFLOW Model

TUFLOW is a computer program for simulating depth-averaged, two and one-dimensional free-surface flows such as occurs from floods and tides. TUFLOW, originally developed for just two-dimensional (2D) flows, stands for Two-dimensional Unsteady FLOW. It incorporates the full functionality of the ESTRY 1D network or quasi-2D modelling system based on the full one-dimensional (1D) free-surface flow equations. The fully 2D solution algorithm solves the full two-dimensional, depth averaged, momentum and continuity equations for free-surface flow. The initial development was carried out as a joint research and development project between WBM Oceanics Australia and The University of Queensland in 1990. The project successfully developed a 2D/1D dynamically linked modelling system. Latter improvements from 1998 to today focus on hydraulic structures, flood modelling, advanced 2D/1D linking and using GIS for data management and linkage with mapping of outputs.

TUFLOW is specifically orientated towards establishing flow patterns in coastal waters, estuaries, rivers, floodplains and urban areas where the flow patterns are essentially 2D in nature and cannot or would be awkward to represent using a 1D network model.

The program was developed by WBM Oceanics Australia over a period of twenty-five years and has been successfully applied on hundreds of investigations ranging from simple single channel applications to complex quasi-2D flood models. The network schematisation technique used allows realistic simulation of a wide variety of 1D and quasi-2D situations including complex river geometries, associated floodplains and estuaries. By including non-linear geometry it is possible to provide an accurate representation of the way in which channel conveyance and available storage volumes vary with changing water depth, and of floodplains and tidal flats that become operable only above certain water levels.

There is a considerable amount of flexibility in the way the network elements can be interconnected, allowing the representation of a river by many parallel channels with different resistance characteristics and the simulation of braided streams and rivers with complex branching. This flexibility also allows a variable resolution within the network so that areas of particular interest can be modelled in fine detail with a coarser network representation being used elsewhere.

The model is based on a numerical solution of the unsteady fluid flow equations (momentum and continuity), and includes the inertia terms. This capability of modelling tidal flow has the added advantage of enabling the tidal portion of a flood model to be calibrated separately using readily

[3] Hoxton Park Airport – Hydraulic Modelling of Flooding, URS, 13 September 2006 (project 43187182/01801).

obtainable measurements of the tide levels and flows. Extension of the calibrated tidal model into the floodplain then results in a more accurate flood model in which the flood channels can be calibrated separately against available flood records.

The type of information provided as output by the model for a flood simulation includes the water levels, flows, and velocities throughout the area being modelled for the simulation period. Other information available includes maximum and minimum values of these variables as well as total integral flows (integrated with time) through each network channel.

TUFLOW is well suited to flooding situations where flow patterns are poorly defined and where flow patterns are likely to change with stage (depth), an accurate description of flooding across the airport site. Cross-catchment flows can also be readily modelled in this format. Future development scenarios, such as changes/filling to the floodplain, can be easily inserted into the model structure without extensive reconstruction of the overall model.

The hydraulic model network adopted for this assessment is based on detailed topographic survey of the floodplain that provides the necessary flood flow definition. The model includes stream channels, overland paths and bridges/culverts. The model is not specifically for the airport site but covers the whole of the Cabramatta Creek catchment. In the area under investigation, the model extends only to the limits of previous modelling and does not extend significant distances into the residential areas east of Cowpasture Road. Accordingly, while there is confidence in the results of the flood investigations up to the 1 in 100 year ARI event, the model does not address any local inflows from the eastern side of Cowpasture road as it is understood these are addressed by Liverpool City Council flood management measures. The hydrographs developed in separate hydrologic studies provide the upstream boundary conditions, with a stage-discharge relationship developed for the downstream boundary.

The model has been calibrated and verified by SMEC using the limited data available for flooding throughout the Cabramatta Creek catchment. The calibration process involved comparing recorded flow hydrographs and flood level data with those simulated by the model. Adjustments were made to the model to represent the changes in topographic conditions between the historic floods used for the validation. Sensitivity analysis of model parameters such as the Manning roughness coefficient was carried out to obtain a good calibration and verification of the model.

Calibration data is limited in the Hinchinbrook Creek area and flood levels estimated by the TUFLOW model must be treated as best estimates only. The modelling undertaken by URS consisted of changing the topographic conditions in and around the airport site to simulate filling of land or establishment of flow paths, and did not involve any calibration or validation of the model. As such, the incremental change calculated in flood level or flow velocity (or other flood parameter) can be used as a reliable measure of impact.

3.3 The Current TUFLOW Model

The version of the SMEC TUFLOW model at the time it was received was Build 2004-06-BA. Previous modelling by Golder Associates for URS and CRDA[4] utilised that build to maintain consistency with the remainder of URS's models, which were all produced with that version of the model. Build 2004-06-BA, however, is now more than 5 years old and is no longer supported by TUFLOW, therefore the

[4] CRDA refers to the Cowpasture Road Design Alliance, formed between URS and the RTA for the design of the upgrade of Cowpasture Road within the area of concern for this Report.

latest version of TUFLOW, Build 2009-07-AE-iDP, was used for all simulations presented herein. Debugging was required as part of the model upgrade.

To validate that the impact of this change was acceptable, the results of a previous simulation undertaken for CRDA (Golder Associates, 2008) was compared to the results of the same simulation executed using the latest version of TUFLOW. It was found that differences in Depth in the 2D domain, within the vicinity of the proposed development, were almost entirely +/- 0.05 m, with only a few exceptions. One of the exceptions was the area immediately upstream of Culvert 1 which showed a change in Depth in the 2D domain of between -0.05 m and -0.15 m, with some cells showing a change of <-0.15 m. The other exception was the area encompassing Basin 18 which showed a change in Depth in the 2D domain of between 0.05 m and 0.15 m. These changes were considered to be minor in the context of this study and, accordingly, Build 2009-07-AE-iDP was utilised for the simulations presented herein without further validation.

It is also to be noted that the study is primarily focused on impact assessment of the proposed development. In this regard, the absolute flood levels are not relevant, rather the difference in flood levels from the pre-development to the post-development conditions.

The other important use of the modelled flood levels is in determining floor levels for the proposed development. The proposed floor levels include appropriate free-board and would therefore have allowance for any changes in the model results such as the above discussed changes due to the model upgrade.

3.4 Conceptual Model

The proposed changes to the Hoxton Park Airport site were implemented within CRDA's existing TUFLOW model. The CRDA model incorporates the upgrade to Cowpasture Road at Hoxton Park. Further details of the implementation of that model are provided in Golder Associates (2008). The base model, from CRDA, that was updated was *GA_SIM-100y2h_MAY08_SSTN_00_01.tcf*.

Changes to that model to incorporate the proposed development at Hoxton Park Airport were implemented via an update to the elevation dataset using Triangular Irregular Network (TIN) files from the 12D civil design package. The 12D TINs were supplied by URS's client, ADW Johnson Pty Ltd (ADW).

During update of the CRDA model to the current version of TUFLOW, some minor reconfiguration of the model with respect to culverts and bridge under Cowpasture Road was undertaken to improve the stability of the model. These changes referred to the treatment of exchange of heads and flows between the 1D and 2D model domains.

To validate the impact of those changes, the difference in modelled maximum discharge through these hydraulic structures was considered by comparing the previous model approach with the updated configuration. It was found that the difference in modelled maximum discharge was within +/-10%, and therefore was considered acceptable.

3.5 Design Flood Events

The100 year Average Recurrence Interval (ARI), 2 hour duration was the only design flood event simulated in TUFLOW. The original documentation provided by SMEC to URS, associated with delivery of the model datasets and license to URS, indicated that this was the relevant critical duration with respect to the 100 y ARI event.

Development Options

4.1 The Development – Existing Conditions

The development proposed for the Hoxton Park Airport site consists of two large warehouses, two smaller warehouse style units and associated road and services infrastructure. The main access road leaves Cowpasture Road, some 250m from the M7 Interchange with Cowpasture Road.

The proposed development requires considerable fill to allow floor levels to be free from flooding for the 1 in 500 year Average Recurrence Interval (ARI) flood – it is understood that this is a condition applying to the users of the warehouse. The access road is to be constructed at and above the 1 in 100 year ARI flood and will intrude into areas previously identified as an area within the then airport's operational boundary identified as being required for minimal impact flood passage.

An initial review of the current development proposal indicated that there may need to be mitigation works to ensure that the flood passage along the east of the access road remained operable, particularly where the flows passed through Flood Relief Culvert No. 1 on Cowpasture Road. These works would take the form of earthworks to direct flows to the culvert as described below (Section 4.2).

Additional field survey undertaken in 2010 by ADW Johnson was used to update the TUFLOW model used by URS for the rezoning investigation of the Hoxton Park airport site and the design of the Cowpasture Road upgrade. The model was modified with improved definition of the creek line, ephemeral drainage lines and an as-built elevation model of the high flow culverts and bridge entries. Additional surface level detail was also gathered immediately adjacent to the properties fronting Ward Place.

The hydraulic behaviour of Hinchinbrook Creek with the improved topography model of the area was rerun in TUFLOW to provide the baseline flooding conditions against which any impacts of the development proposal on the flooding regime of the area would be assessed.

4.2 Mitigation Options

4.2.1 Mitigation Scenario 1

As a result of the previous modelling undertaken by URS as part of the rezoning study for the site and the design of the Cowpasture Road upgrade, it was clear that the introduction of the Access Road along the eastern site boundary at a level at or in excess of the 1:100 ARI flood level would necessarily increase flooding levels in the Hinchinbrook Creek floodplain. As a starting point for the development of design strategies, a floodway was proposed as an entry to Culvert 1 between the proposed Access Road and the existing service station site.

The proposed floodway was designed at approximately the high flow culvert entry level to improve the conveyance of floodwater into the culverts constructed as part of the Cowpasture Road upgrades. Generally the channel was proposed to be a minimum of 30m wide from the existing service station site adjacent to the proposed access road. Batter slopes from the proposed road were set at 1V:4H adjacent to the road with the service station site lifted in the flood model to simulate flood free conditions for the service station. During detailed design of the development, due consideration will be required of the flooding level to determine if adjustments to the existing berms protecting the service station are required.

The baseline TUFLOW model was updated to include this floodway and reflect the desired flood free status of the service station. The design surface model of the proposed access road was also incorporated into the updated baseline model.

4.2.2 Mitigation Scenario 2

The results of the Simulation 1 model run indicated flooding level increases greater than 0.15m in some limited areas along with increased floodplain velocities. In order to improve the conveyance through the flood relief culverts, and assess the sensitivity of the flooding level increases to the configuration of the Culvert entry, modifications were made within the floodway to the Culvert 2 entry. These changes consisted essentially in minor earthworks within the floodplain to extend the length of the Culvert 2 entry by some 80m to the north.

This amended topographic model was incorporated into the Scenario 1 model and rerun to determine impacts and benefits.

The results of the modelling are presented in Section 5.

4.3 Model Simulations

Within the constraints described above, three models were constructed:

- Existing Conditions
- Mitigation Scenario 1 (Simulation 1)
- Mitigation Scenario 1 (Simulation 2)

The TUFLOW control files associated with the results presented herein are provided for documentation purposes:

- GA_EXIST_20.tcf = 100 y 2h ARI design flood event (Existing Condition)
- GA_SIM1_35.tcf = 100 y 2h ARI design flood event (Simulation 1)
- GA_SIM2_10.tcf = 100 y 2h ARI design flood event (Simulation 2)

Details of each model simulation are provided below.

4.3.1 Existing Conditions

This model reflects changes to TUFLOW from the original SMEC model of the Westlink/M7 by URS, which was subsequently updated to reflect CRDA's design for Cowpasture Road by Golder Associates. It is noted that the CRDA TUFLOW model incorporated the *Optimised Development* scenario, as reported in URS (2006), for Hoxton Park Airport.

Following debugging of the TUFLOW model to the latest version of TUFLOW, Build 2009-07-AE-iDP, the changes pertaining to the *Optimised Development* were removed from this Existing Condition simulation.

URS has indicated that the CRDA design, as modelled, was implemented without significant changes and that the model provided to CRDA remained a suitable representation of the implemented Cowpasture Road upgrade.

It is noted that the CRDA design incorporated bunding of the Service Station on Cowpasture Road and this was retained in the TUFLOW model of existing conditions but was removed in subsequent simulations since the Service Station was assigned flood-free status in those simulations.

4 Development Options

Model Elevation Domain Construction

The elevation dataset of the Existing Condition model was then updated using a 12D TIN provided by ADW of CRDA's design for Cowpasture Road (*tin URS DESIGN.12da*). This file was used to update the surface elevations of the upgraded Cowpasture Road. Changes to the elevation dataset for the upgrade of Cowpasture Road, which was already in the TUFLOW model, were essentially negligible since they were based on the same design. The 12D approach was adopted mostly so that the proposed earthworks, discussed below, could be readily implemented in TUFLOW from 12D without significant pre-processing.

The elevation dataset of the Existing Condition model was then updated from a new ground survey undertaken by URS's client, ADW. This update (*tin ISG SVY 100223.12da*) was provided in 12D TIN format.

There were some earthworks designed and undertaken by CRDA following completion of TUFLOW modelling by Golder Associates (2008). These works were located adjacent Ward Place, Hinchinbrook, on the south side of Hinchinbrook Creek bridge, and consisted of refinement of the upper part of the diversion channel of the tributary that runs between Cowpasture Road and Ward Place. That diversion channel was incorporated into TUFLOW using a 2d_zln_gully line object, discussed below.

The previously implemented 2d_zln_gully line objects that defined the low-flow channel through Hinchinbrook Creek bridge and other channel lines in the vicinity of Cowpasture Road were then re-applied.

These gully line objects incorporated the refinements described for Ward Place.

The bunding around the Service Station on Cowpasture Road was then re-applied and the model executed.

4.3.2 Simulation 1

This model is based on the Existing Condition model presented above. The proposed development was represented by incorporating the following changes to the Existing Condition model:

- earthworks adjacent to the entrance of Culvert 1 and along the proposed access road;
- implementation of the small detention basin in the southwest corner of the site;
- assigning flood-free status to the development area, west of the proposed road; and
- assigning flood-free status to the paved area of service station.

Model Elevation Domain Construction

The new ground survey in the vicinity of the development site was implemented using a 12D TIN from ADW (*tin ISG SVY SIM1.12da)*. This TIN was essentially the same as *tin ISG SVY 100223.12da*, amended such that there wasn't overlap between the proposed earthworks and new ground survey. The CRDA design (*tin URS DESIGN.12da*) was then implemented and the earthworks adjacent the entrance of Culvert 1 and along the proposed access road was then implemented (*tin_EARTHWORKS.12da*).

The relevant 2d_zln_gully line objects that defined the low-flow channel through Hinchinbrook Creek bridge and other channel lines in the vicinity of Cowpasture Road were then re-applied.

The small detention basin lies in the southwest corner of the site was digitised based on plans supplied by ADW (*MGA.dwg*) and implemented using a 2d_zpt_polygon object.

Finally, flood-free status was assigned to the development area, west of the proposed road as well as the paved area of the Service Station using a 2d_zpt_polygon object that added 5 m to the underlying elevation dataset. The extent of the assigned flood-free areas is indicated in Figure 1.

4.3.3 Simulation 2

This model is based on Simulation 1 presented above. This simulation scenario was represented by

incorporating the following changes to the Simulation 1 model:

- earthworks at the entrance to Culvert 2

Model Elevation Domain Construction

The same update to the ground survey was applied to Simulation 2 as Simulation 1 (*tin ISG SVY SIM1.12da)*, as well, the CRDA design (*tin URS DESIGN.12da*) and then the earthworks adjacent the entrance of Culvert 1 and along the proposed access road was implemented (*tin_EARTHWORKS.12da*).

The relevant 2d_zln_gully line objects that defined the low-flow channel through Hinchinbrook Creek bridge and other channel lines in the vicinity of Cowpasture Road were then re-applied and the location of the small detention basin was implemented.

The earthworks at the entrance to Culvert 2 were then implemented based on a 12D TIN provided by ADW (*tin_SCENARIO2_DATA.12da*) and a single 2d_zln_gully line was then re-applied such the fine detail of that minor creek line was incorporated back into the model.

Finally, flood-free status was assigned to the development area, west of the proposed road, as well as the paved area of the Service Station.

Flood Modelling Results

5.1 Model Results

The TUFLOW models were executed using the latest version of TUFLOW, Build 2009-07-AE-iDP. It is noted that all model results pertain to the 100 y 2 h design flood event.

2D model results are presented in the following figures. These figures include flood impact assessment plots as well as general model output.

- Figures 1 to 3 present the modelled change in maximum flood depth, maximum velocity and maximum provisional flood hazard class associated with Simulation 1 compared to Existing Conditions.
- Figures 4 to 6 present the modelled change in maximum flood depth, maximum velocity and maximum provisional flood hazard class associated with Simulation 2 compared to Existing Conditions.
- Figures 7 to 9 present the modelled maximum flood depth, maximum modelled velocity and modelled maximum provisional hazard class for Existing Conditions.
- Figures 10 to 12 present the same model outputs (depth, velocity and hazard) for Simulation 1.
- Figures 13 to 15 present those model outputs (depth, velocity and hazard) for Simulation 2.

It is noted for all flood impact figures, except within the 1D domain associated with Hinchinbrook Creek, where there was no change in modelled depth, velocity or provisional hazard class, then no colour was assigned to the particular model cell. As an example if the change in modelled depth was more than 0 cm to 5 cm or less than 0 cm to -5 cm then the model cell would be coloured yellow, whereas if the change was exactly 0 cm then the model cell would be clear.

It should be noted that, for ease of presentation and to avoid overstating the absolute accuracy of the model, limited ranges of impact variations are plotted on these figures. This approach does mean that a change of flood level of 10mm would plot in the same area as a change of 50mm. Such changes are considered incremental in nature and are generally marginal within the entire floodplain. Only where there are significant changes will detailed comment be made.

Table 1 presents modelled maximum flood velocities within 1D elements representing structures under Cowpasture Road.

Table 5-1 Modelled Maximum Velocities (m/s) in 1D Elements

Culvert ID	Existing Conditions	Simulation 1	Simulation 2
	EXIST_20	*SIM1_35*	*SIM2_10*
Hinchinbrook Creek			
2004	0.16	0.28	0.27
2000	0.99	1.10	1.10
2001	0.76	0.87	0.87
2002	0.56	0.60	0.60
2003	0.85	0.88	0.88
Culvert 2			
1110	0.99	0.61	0.61
1111	0.89	0.54	0.55
1112	1.23	0.92	0.92
Culvert 1			
3000	1.30	1.43	1.43
3001	1.51	1.49	1.49

A plot of modelled discharge (in 2D) over the centreline of Cowpasture Road is presented in APPENDIX A.

A plot of modelled discharge through 1D elements representing structures under Cowpasture Road is presented in APPENDIX B.

5.2 Discussion

Modelling results indicate that there is a change in maximum modelled depth and maximum modelled velocity associated with the proposed development with respect to both Simulation 1 and Simulation 2.

5.2.1 Simulation 1

Figure 1 indicates that the change in modelled flood depth ranges between 5 cm to more than 15 cm adjacent the development area, and between 5 cm and 10 cm immediately downstream of Hinchinbrook Creek bridge. In general, the modelled impact of the development implies there is a reallocation of floodwaters toward Hinchinbrook Creek bridge. Model results indicate, however, that the modelled change in flood depth downstream of Hinchinbrook Creek does not extend up to the houses along Ward Place, Hinchinbrook, immediately adjacent the tributary. Figure 1 indicates the modelled change in flood depth in Basin 18, the detention basin downstream of Cowpasture Road, is less than 5 cm. There are local impacts to modelled flood depth indicated in Figure 1, associated with the Northern Floodway.

Figure 2 indicates a general increase in modelled flood velocity of between 0.1 and 0.5 m/s along the eastern edge of the proposed development area, with changes of more than 0.5 m/s at the entrance to Culvert 2. The modelled change in flood velocity at the entrance to Culvert 1 is a decrease of between 0.1 and 0.5 m/s, interpreted to be caused by increased flood depth.

Figure 3 indicates an increase of one hazard class along the eastern edge of the proposed development area and an increase of two hazard classes in the vicinity of the Service Station and at the entrance to Culvert 1, however, there is no indication of an increase in hazard class along the centreline of Cowpasture Road itself. The increase in hazard class at the entrance to Culvert 1 is interpreted to be due to increased flood depth.

5.2.2 Simulation 2

Figure 4 indicates the change in modelled flood depth still ranges between 5 cm to more than 15 cm adjacent the development area, and between 5 cm and 10 cm immediately downstream of Hinchinbrook Creek bridge. Model results indicate that the extent of the “more than 15 cm” impact area, adjacent the development, is less in Simulation 2 compared to Simulation 1. The modelled increase in flood depth in Basin 18 is again less than 5 cm.

Figure 5 indicates a general increase in modelled flood velocity of between 0.1 and 0.5 m/s along the eastern edge of the proposed development area, however, the area of change of more than 0.5 m/s at the entrance to Culvert 2 is less in Simulation 2 compared to Simulation 1. The modelled change in flood velocity at the entrance to Culvert 1 is a decrease of between 0.1 and 0.5 m/s.

Figure 6 indicates a general increase of one hazard class along the eastern edge of the development area and an increase two hazard classes in the vicinity of the Service Station and at the entrance to Culvert 1.

5 Flood Modelling Results

The modelled increase in hazard is comparable to that presented for Simulation 1, with a couple more cells indicating an increase of two hazard classes near the entrance to Culvert 2, interpreted to be associated with the new earthworks represented in this simulation. Figure 6 indicates, however, that there is no modelled increase in hazard class along the centreline of Cowpasture Road itself.

External Impacts

6.1 Cowpasture Road – RTA

The design standard for the upgrade of Cowpasture Road called for flood immunity to the 1 in 20 year ARI flood and was designed to be overtopped at both Flood Relief Culverts under flood conditions greater than that standard. Under existing conditions, the overtopping in a 1 in 100 year ARI flood occurs over slightly more than 1 hour (see Appendix C). The overtopping of Cowpasture Road occurs, as designed, to the section of road over the two flood relief culverts and does not affect the intersection of Cowpasture Road and the planned access road.

Both Scenario 1 and Scenario 2 improve the flooding situation to some degree as overall flood levels and flow velocities across Cowpasture Road are reduced, though the time of overtopping remains consistent with the existing situation. There is a small increase in velocity across the road (within the range of 0.1 – 0.5 m/s) in the area between Culvert No. 1 and the western side of the service station with an existing situation (no development) velocity up to a maximum of 1.2m/s. Such increases are within the design tolerances and accuracy of the model. The velocity changes within the structures themselves are all within the design tolerances for the upgrade and the currently designed erosion control works will be adequate for that purpose.

It should be noted that the emergency management plan (prepared by NSW State Emergency Service) for Cowpasture Road in this area includes the requirement to close the road under major flood conditions. Not only is the road flooded at the culverts but it is also cut in two other locations where local runoff surcharges the existing residential drainage system.

The flow management works will require opening up some of the currently vegetated areas, and it will be essential that erosion control works are included in the overall design for the area. It would be appropriate if these were refined and linked to the works under construction as part of the Cowpasture Road upgrade.

The proposed development will not have any adverse impact on the operation and maintenance of Cowpasture Road.

6.2 Liverpool City Council

The following discussion addresses issues raised by Liverpool City Council in discussions with the developers.

6.2.1 Hazard Assessment

The existing situation modelling (Figures 7, 8 & 9) indicate that with the exception of the areas closest to creek channel, the flood hazard based on a depth x velocity criteria is low across the floodplain. This is essentially because the velocity of flow is quite low and depths are generally less than 1.0m.

The Change in Flood hazard (Figures 3 & 6) indicate that this hazard rating changes to moderate in some areas closest to the development and only where the flows are concentrated prior to passing through Flood Relief Culvert No. 1 does a significant change of hazard occur.

These changes are not considered significant as the overall change essentially raises the depth x velocity quantum to slightly above 1.0. The area will be landscaped in such a fashion to limit access to the floodplain thus taking reasonable steps to mitigate any risks in a flood situation.

6.2.2 Impacts on Residential Areas

There is significant residential development east of Cowpasture Road and Liverpool City Council has a range of flood management measures in the area. The area of interest is an open space/ephemeral watercourse that flows north and west of Ward Place. Under 1 in 100 year ARI flood conditions, there is some backwater flooding in this watercourse, as well as flooding from its upstream catchment. Under existing conditions, backwater flooding is observed in the vicinity of 21 and 23 Ward Place, though it is generally less than 0.2m in depth. The floor levels of these properties have a freeboard to the flood level of 0.5m.

As indicated previously, some increase in flood levels is identified in this watercourse (Figures 1 & 4) however these increases effectively stop at an existing drop structure in that tributary and do not threaten flooding of any properties in Ward Place. There is no change in flood level, flow velocity or flood hazard upstream of the drop structure and all properties retain their existing freeboard above the estimated 1 in 100 year ARI flood level.

The development scenarios as modelled do not pose any threat of flooding to these properties.

6.2.3 Adjacent Property Impacts

There are some increases in flood level and velocity in the area known as the Bus Depot. These are generally small increases on a small base (e.g., +/- 0.05m on an existing 0.2m depth). The Bus Depot will be in the shadow of the northern access bridge (currently in investigation/design stages) and mitigation measures will be incorporated into that work to mitigate any impacts.

Downstream of Cowpasture Road, under existing conditions, there are no significant changes to flood levels, flow velocity or flood hazard. The changes that are indicated by the model are of minor proportions (-0.05 to +0.05m), particularly when the existing situation indicates that flood depths in the area can be up to or greater than 1.0m. In the areas of concern, the results indicate a maximum increase in flood level of 0.02m (20mm) which is within the range of variations that could be expected under actual flooding conditions.

It is considered that any changes to the flooding regime in the areas downstream are outside the tolerances of the model and are thus neutral in overall impact.

6.2.4 Changes in Velocity within the Floodplain

As noted in Section 6.1, there are small increases in flow velocities across Cowpasture Road and within the flood relief culverts. These changes in velocity are within the design parameters of these works and no adverse impacts are expected there.

Within the flood affected area, there are some changes to the flow velocity, generally in the range from 0.1m/s to 0.5m/s, with some isolated areas, close to the proposed road, where increases are greater then 0.5m/s. Under existing conditions (figure 8), velocities within the floodplain velocities generally range from 0.4m/s to 1.2m/s – only in the deeper flowing floodway do velocities exceed this upper value.

While the increases as a result of the development appear high from a percentage viewpoint, the starting point (existing velocity) is very low, reflecting the relatively flat terrain of the floodplain and the absolute changes are considered to be within acceptable limits. The estimated velocities under both existing and developed scenarios are not great enough to induce any significant erosion within the floodplain.

6.2.5 Flood Duration and Flood Storage

Hydrographs of the flood as it passes through and over Cowpasture Road are provided in Appendices B and C. These indicate minimal variation in the shape and timing of the flood hydrograph and thus it is considered that the proposed development has no impact on the duration of flooding.

The Floodplain development Manual (NSW Government 2005) defines flood storage areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. This flood storage definition refers more to long-period, broad-acre storage areas and not the usually occurring attenuation of a flood as the waters flow over the floodplain, rather than in the faster flowing stream channel. As such, it is difficult to nominate any area within the Hinchinbrook floodplain as flood storage.

The flood storage that occurs in the floodplain adjoining this proposed development could be considered as dynamic storage, rather than a passive storage of significant volumes of water. This is best demonstrated by an assessment of the time to peak and time of peak flows. Appendix C shows the hydrographs for the flood under developed and existing conditions.

The duration of the flood and the duration of the peak flow is minimally affected by the development, the only change to "flood storage" in the area could be the relative changes in depth that will occur within the Environmental Zone. As these changes are confined to specific areas and the downstream impacts of depth change, velocity change and potential hazard change are minimal, there is no loss of flood storage as a result of the development.

6.2.6 On-Site Stormwater Detention

Liverpool City Council has a specific On-Site Stormwater Detention (OSD) Policy that covers the proposed development. It covers the proposed development in that the development will "involve an increase in impervious area on the site" (Policy Statement, Section 2). However, Section 3 of the Policy indicates that OSD will not be required where "the increased discharge for all storms up to and including a 100 year event can be accommodated by the existing stormwater pipe system".

The stormwater design for the proposed development makes allowance for both the tributaries of Hinchinbrook Creek that drain areas west of the M7 and pass under the M7, running through the airport site under existing conditions, as well as the runoff from the new buildings. All tributary flows pass through a retarding basin in the south-west corner of the site either directly or via a spill containment structure built as part of the M7 construction – non- contaminated flows pass along an open channel to the retarding basin. These works are designed to retain flows and then gradually release to the larger retarding basin downstream of Cowpasture Road.

Runoff from the developments (roadways and roofs) is designed to generally mirror the existing drainage pattern where runoff from the airport surface and surrounds enters the floodplain of Hinchinbrook Creek through small "gullies" along the western boundary of the Environmental Zone. It is understood that the issues relating to this are being addressed in the detailed design of the development.

6 External Impacts

Basin 6 is located on the northern tributary that passes through the airport site. Under neither existing nor proposed conditions does any runoff enter that stream from the development area. The need or otherwise for OSD in the proposed development does not depend on the implementation of Basin 6; they are in separate catchments and there is no inter-catchment transfer of water/runoff.

7

Conclusion

Based on the currently proposed development scenarios, flood levels in the 1 in 100 year ARI flood will increase to the greatest degree within the Environmental Zone east of the former airport and in the approaches to the Flood Relief Culverts constructed as part of the Cowpasture Road upgrade. Changes to flow velocity and flood hazard are also confined to these areas. All flood impacts are confined to areas that will not be subject to future development.

The development of the Hoxton Park Airport site as currently proposed could take place under these conditions.

References

Golder Associates Pty Ltd, 2008. *Report on Hydraulic Analysis of Cowpasture Road at Hoxton Park.* Reference No. 087626016/004 Rev2. Sydney, NSW.

URS Australia Pty Ltd, 2006. *Hoxton Park Airport – Hydraulic Modelling of Flooding*. Reference No. 43187182.01801. Sydney, NSW.

Limitations

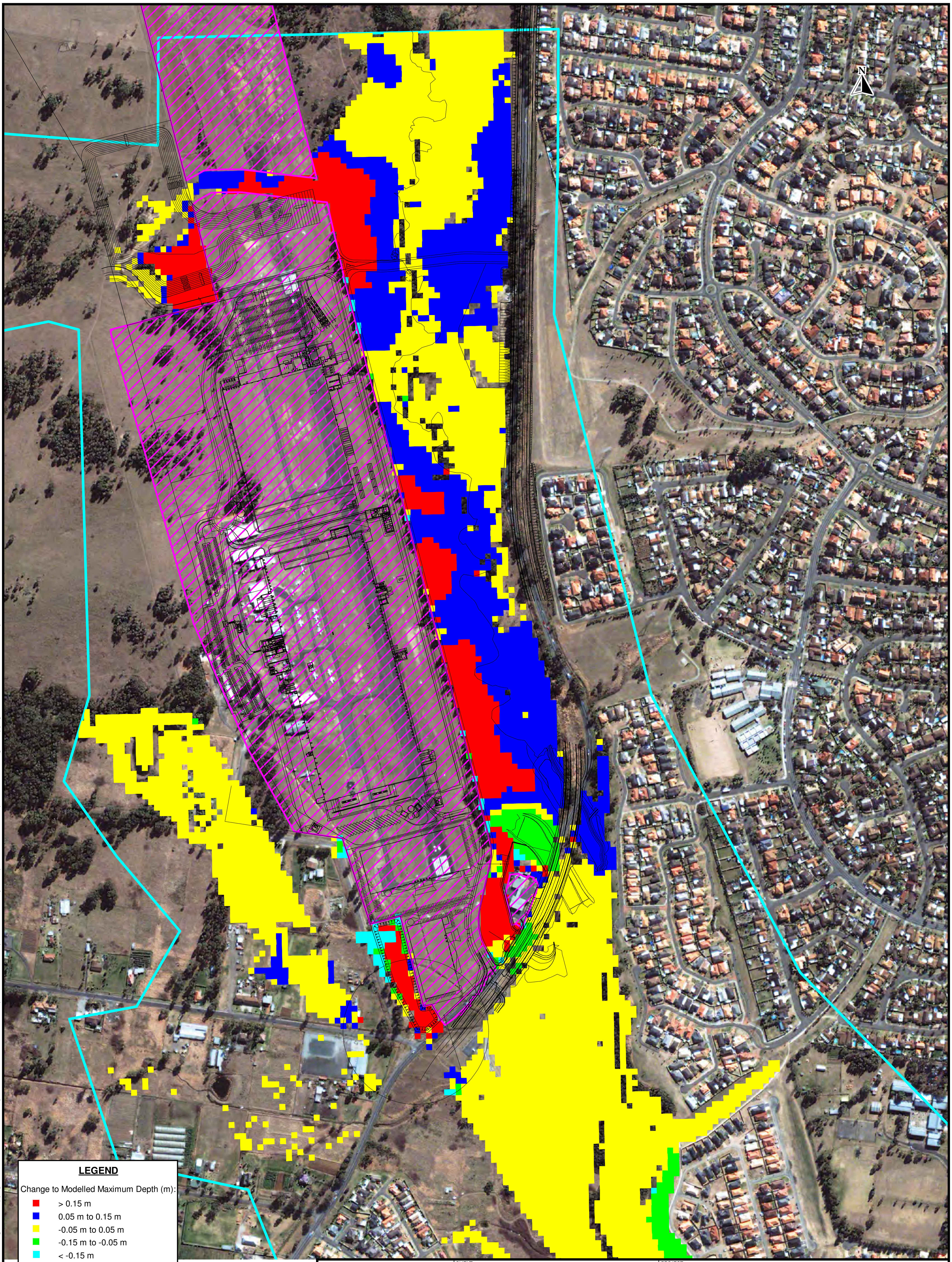
URS Australia Pty Ltd (URS) as prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Mirvac Projects Pty Ltd and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 11 January 2010.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 8 March 2010 and 19 March 2010 and is based on the situation as described in the report. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendix A Figures



Golder Associates

CLIENT	URS Australia Pty Ltd			PROJECT	FORMER HOXTON PARK AIRPORT SITE		
DRAWN	JRB	DATE	11-03-10	TITLE	SIMULATION 1 - 100Y2H Change in Maximum Flood Depth		
CHECKED	HR	DATE	11-03-10				
SCALE	1:6,000			PROJECT No 107626023	FIGURE No 1	REV No 1	A3

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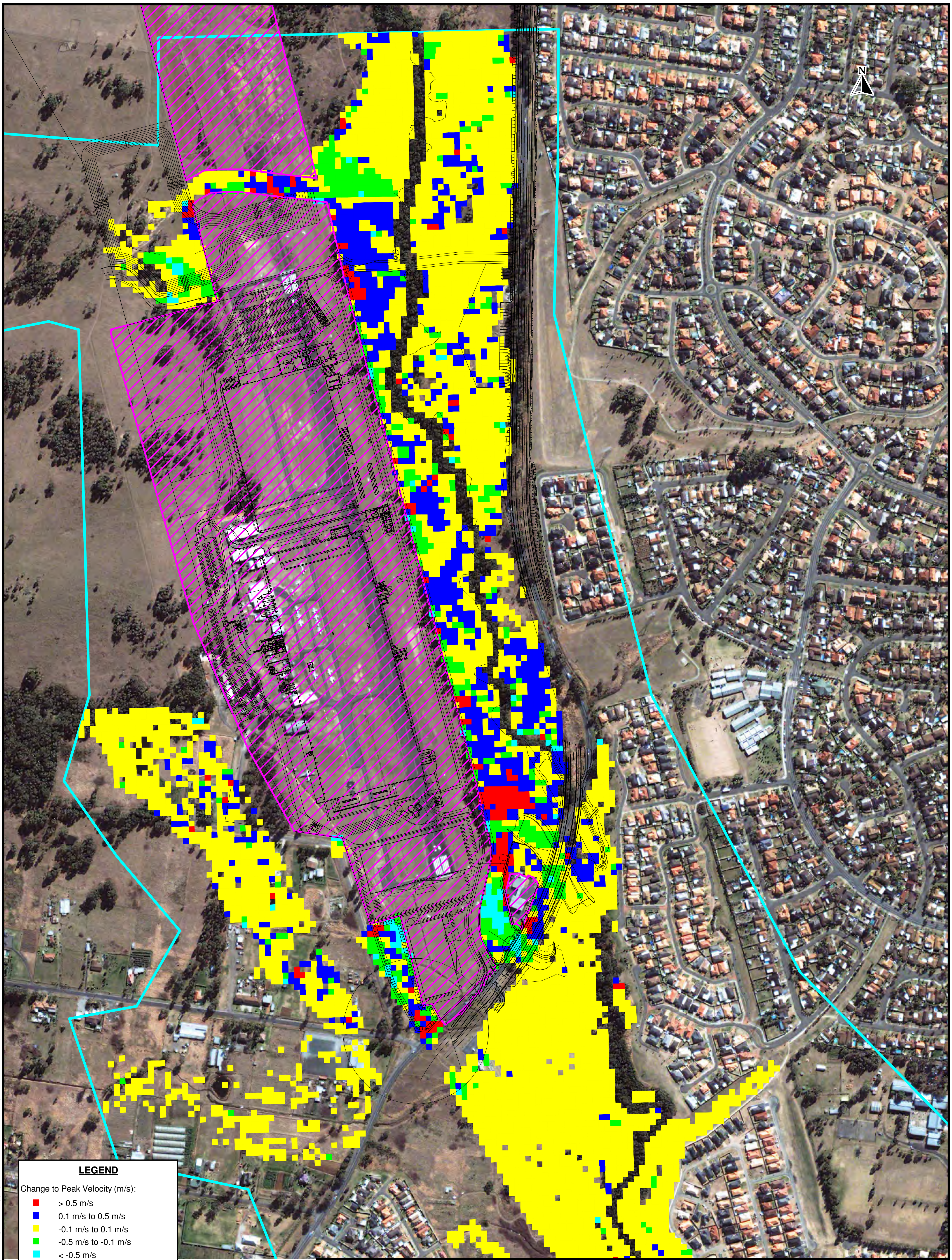

Golder Associates

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DRAWN	JRB	DATE	11-03-10
CHECKED	HR	DATE	11-03-10
TITLE	**SIMULATION 1 - 100YR Change in Maximum Velocity**		
SCALE	1:6,000	PROJECT No	107626023-001
FIGURE No	2	REV No	1
A3			

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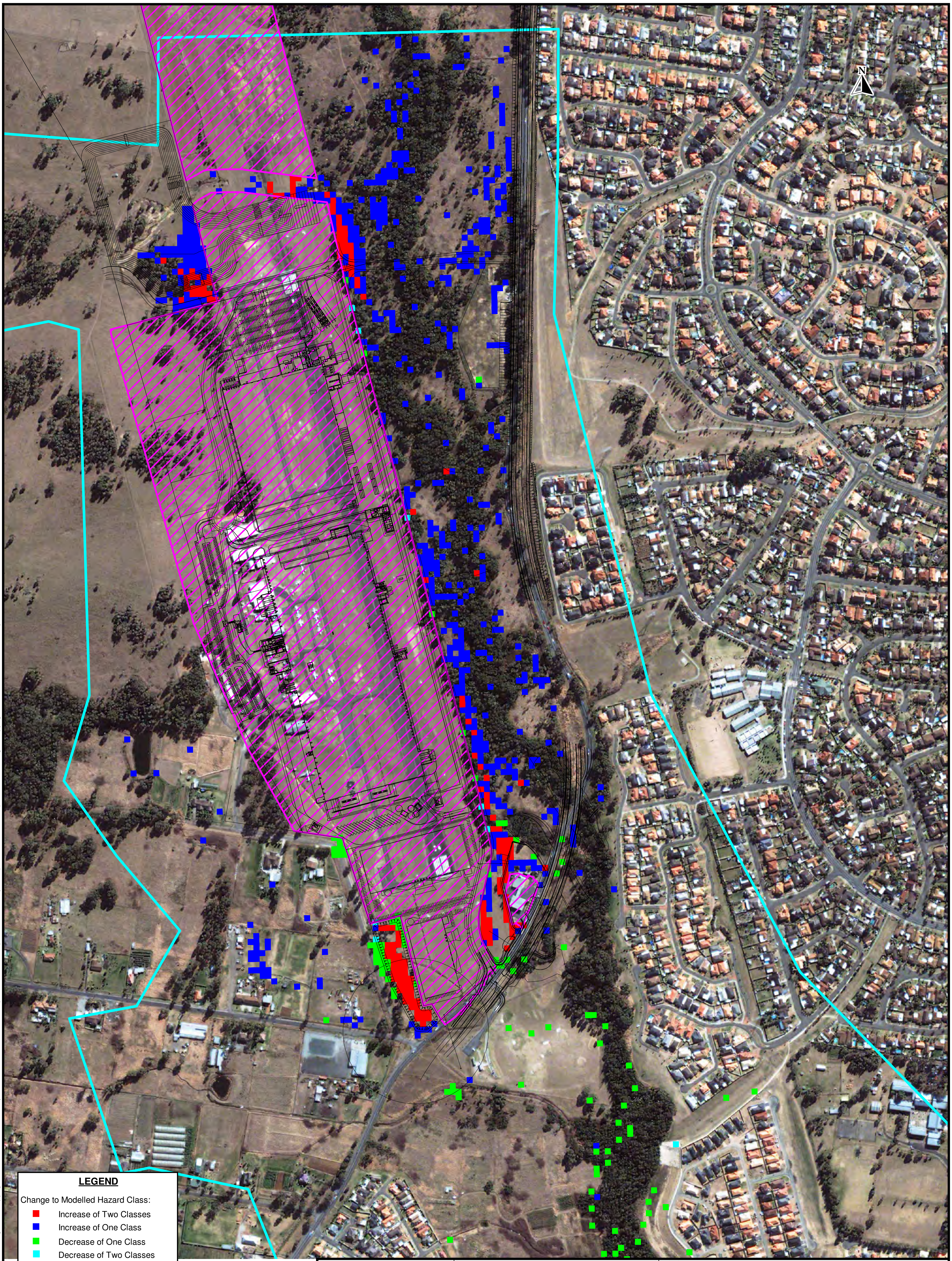

LEGEND

Change to Modelled Hazard Class:

- Increase of Two Classes
- Increase of One Class
- Decrease of One Class
- Decrease of Two Classes

General Items:

- Modelled Development Area
- Model Domain

Note: Datum GDA94, Projection MGA94Z56

Golder Associates

CLIENT: URS Australia Pty Ltd		PROJECT: FORMER HOXTON PARK AIRPORT SITE	
DRAWN: JRB	DATE: 11-03-10	TITLE: SIMULATION 1 - 100Y2H Change in Maximum Flood Hazard Class	
CHECKED: HR	DATE: 11-03-10		
SCALE: 1:6,000		PROJECT No: 107626023-001	FIGURE No: 3 / REV No: 1 / A3

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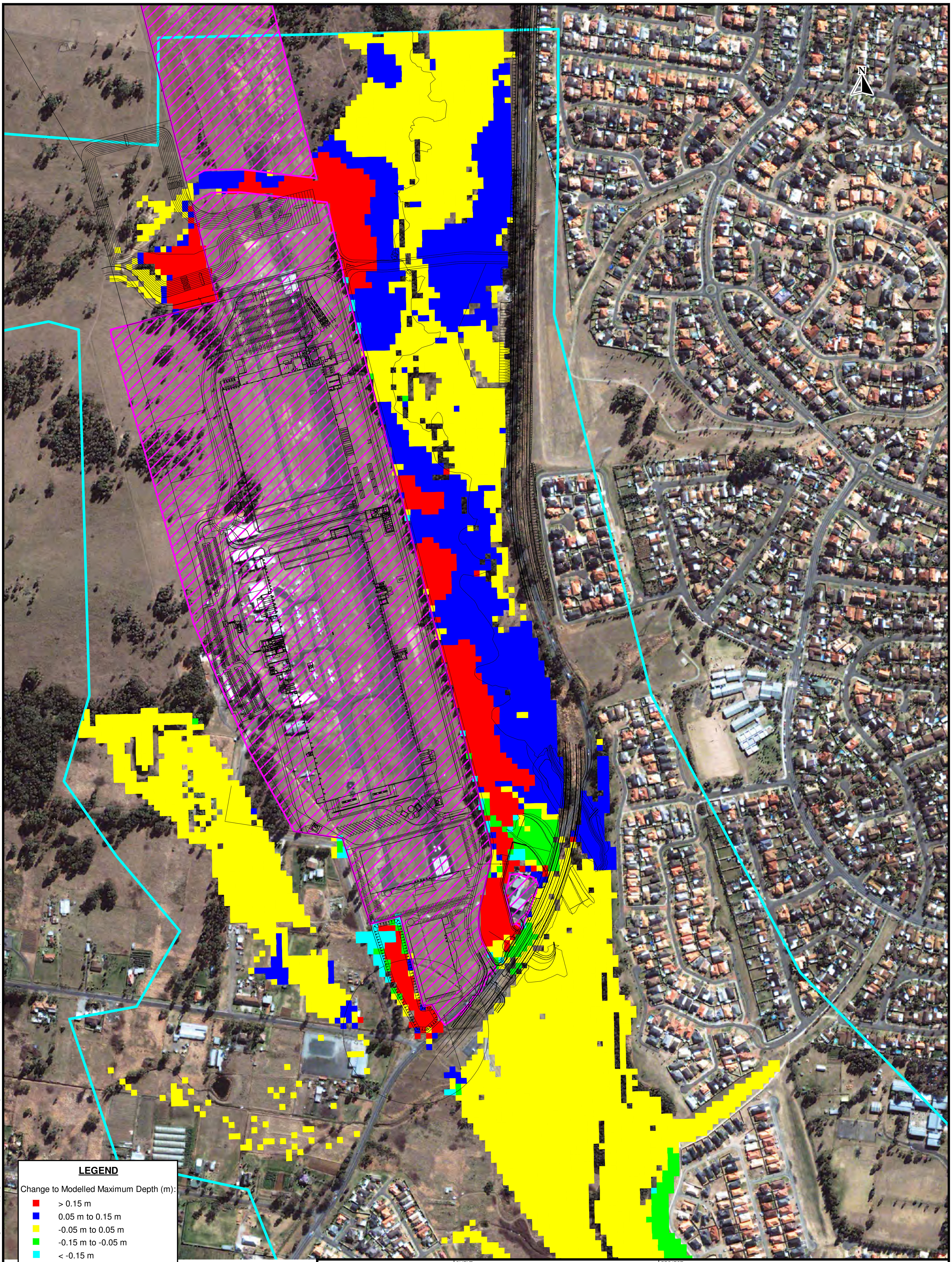

LEGEND

Change to Modelled Maximum Depth (m):

- > 0.15 m
- 0.05 m to 0.15 m
- -0.05 m to 0.05 m
- -0.15 m to -0.05 m
- < -0.15 m

General Items:

- Modelled Development Area
- Model Domain

Note: Datum GDA94, Projection MGA94Z56

CLIENT	URS Australia Pty Ltd	PROJECT	FORMER HOXTON PARK AIRPORT SITE
DRAWN JRB	DATE 11-03-10	TITLE	SIMULATION 2 - 100Y2H Change in Maximum Flood Depth
CHECKED HR	DATE 11-03-10		
SCALE	1:6,000	PROJECT No 107626023-001	FIGURE No 4 · REV No 1 · A3

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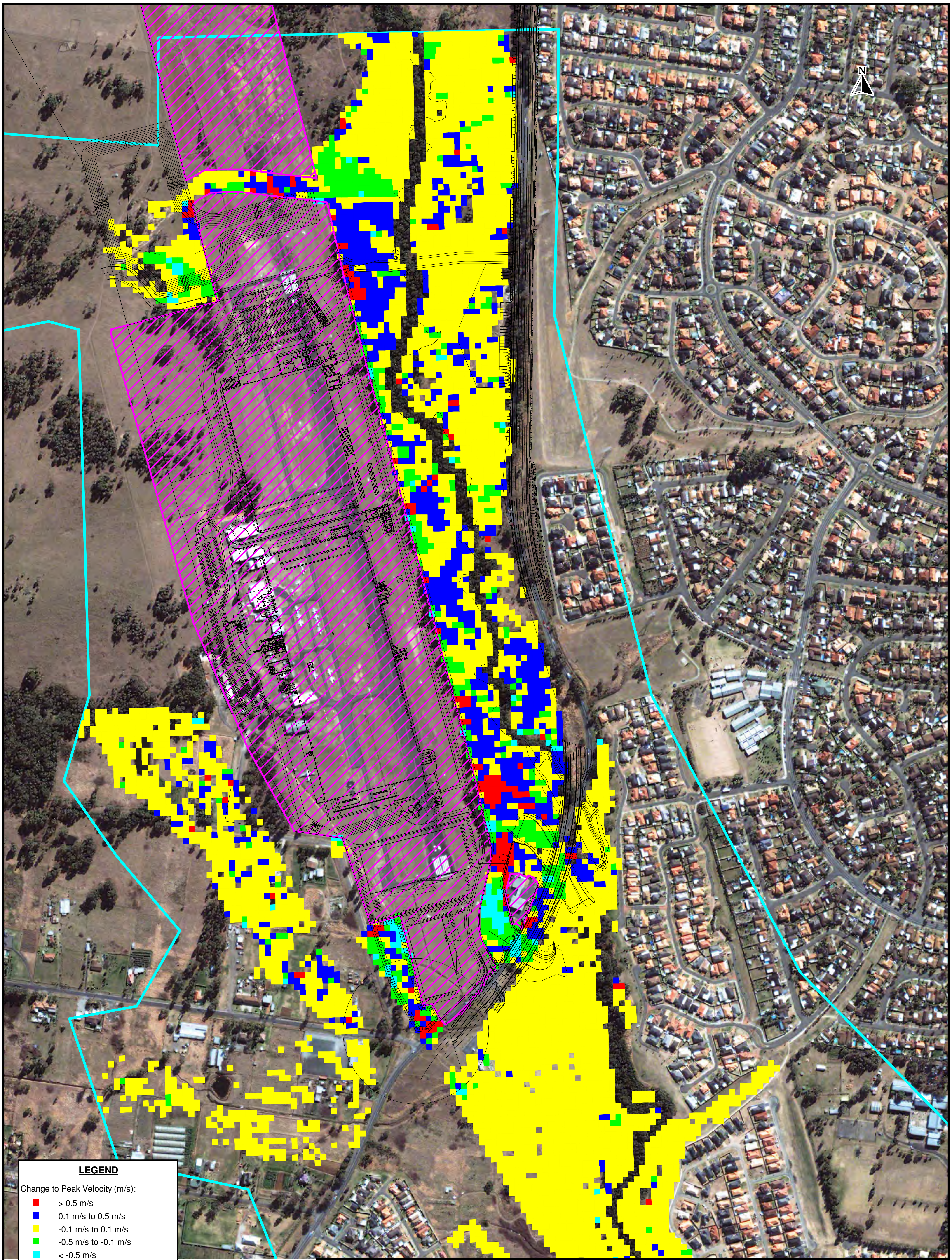

LEGEND

Change to Peak Velocity (m/s):

- > 0.5 m/s
- 0.1 m/s to 0.5 m/s
- -0.1 m/s to 0.1 m/s
- -0.5 m/s to -0.1 m/s
- < -0.5 m/s

General Items:

- Modelled Development Area
- Model Domain

Note: Datum GDA94, Projection MGA94Z56

CLIENT	URS Australia Pty Ltd		PROJECT	FORMER HOXTON PARK AIRPORT SITE	
DRAWN	JRB	DATE 11-03-10	TITLE	SIMULATION 2 - 100Y2H Change in Maximum Velocity	
CHECKED	HR	DATE 11-03-10			
SCALE	1:6,000		PROJECT No 107626023-001	FIGURE No 5	REV No 1 A3

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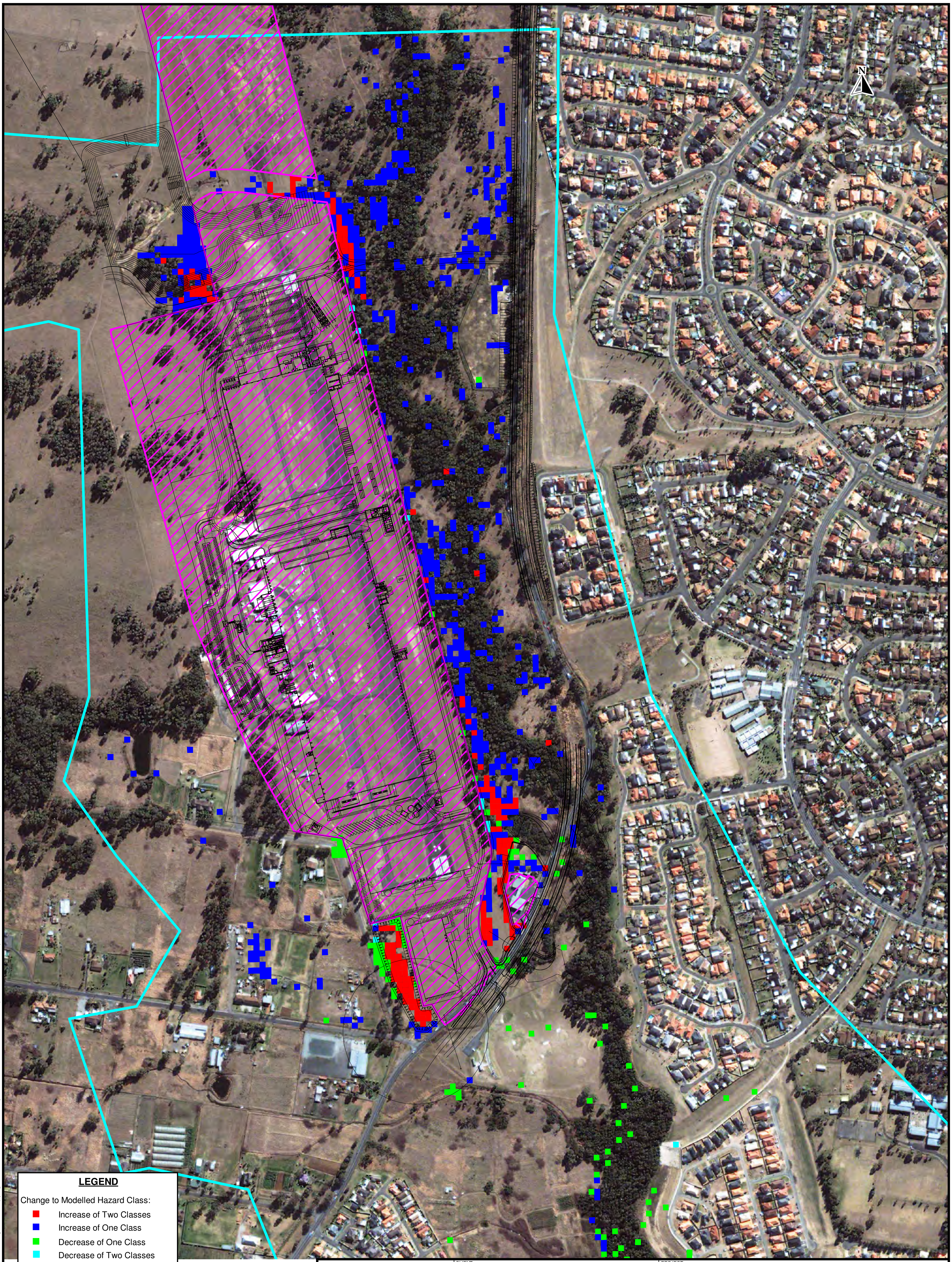

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DRAWN JRB	DATE 11-03-10	TITLE	**SIMULATION 2 - 100Y2H**
CHECKED HR	DATE 11-03-10		**Change in Maximum Flood Hazard Class**
SCALE	1:6,000	PROJECT No 107626023-001	FIGURE No **6** REV No **1** A3

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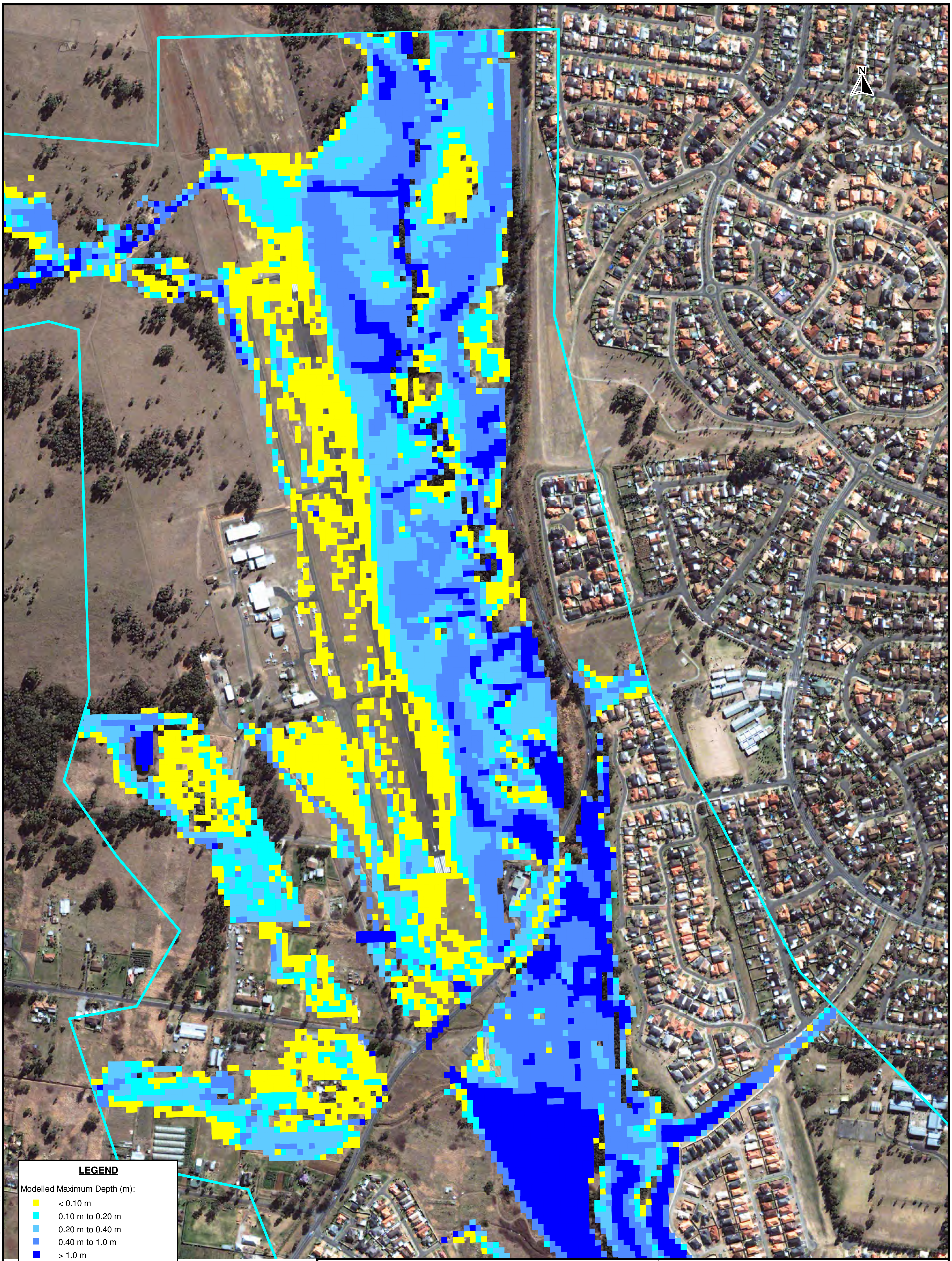

LEGEND

Modelled Maximum Depth (m):

- < 0.10 m
- 0.10 m to 0.20 m
- 0.20 m to 0.40 m
- 0.40 m to 1.0 m
- > 1.0 m

General Items:

- Modelled Development Area
- Model Domain

Note: Datum GDA94, Projection MGA94Z56

CLIENT: URS Australia Pty Ltd		PROJECT: FORMER HOXTON PARK AIRPORT SITE	
DRAWN: JRB	DATE: 25-03-10	TITLE: **EXISTING CONDITION - 100Y2H Maximum Flood Depth**	
CHECKED: HR	DATE: 25-03-10		
SCALE: 1:6,000		PROJECT No: 107626023-001	FIGURE No: 7 REV No: 0 A3

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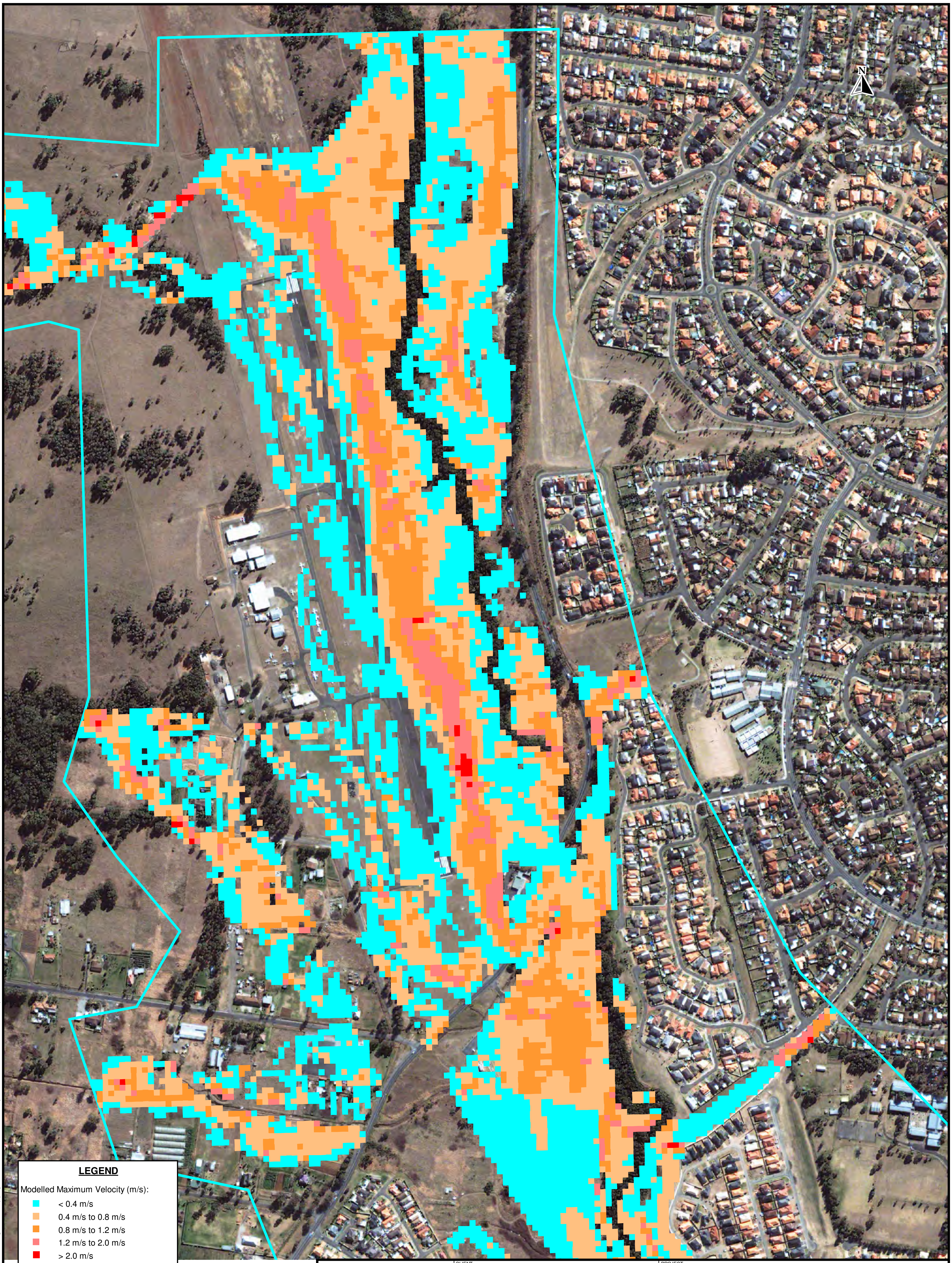

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CLIENT	URS Australia Pty Ltd	PROJECT	FORMER HOXTON PARK AIRPORT SITE
DRAWN JRB	DATE 25-03-10	TITLE	EXISTING CONDITION - 100Y2H Maximum Flood Velocity
CHECKED HR	DATE 25-03-10		
SCALE 1:6,000		PROJECT No 107626023-001	FIGURE No 8 · REV No 0 · A3

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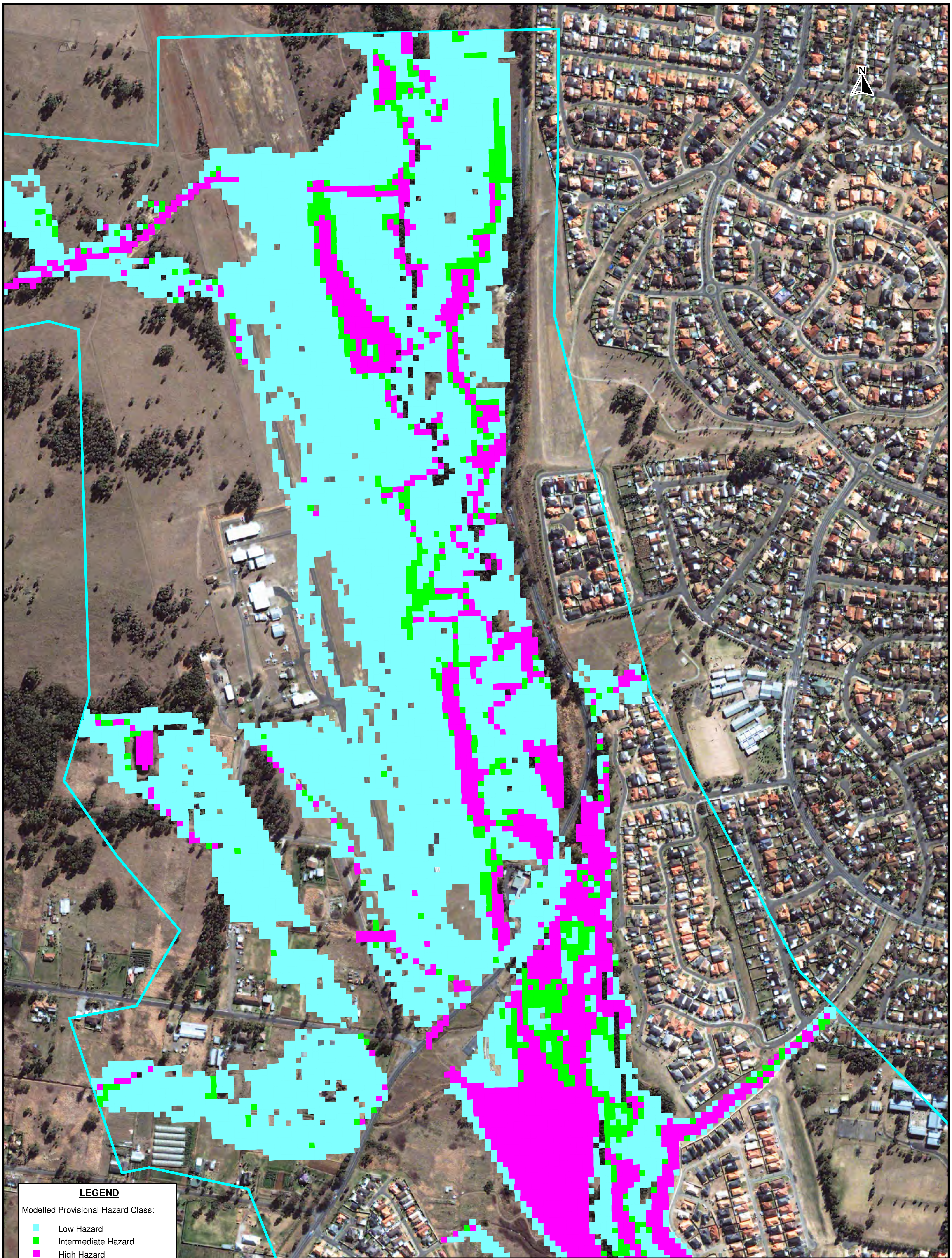

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	CHECKED	HR	DATE 25-03-10		
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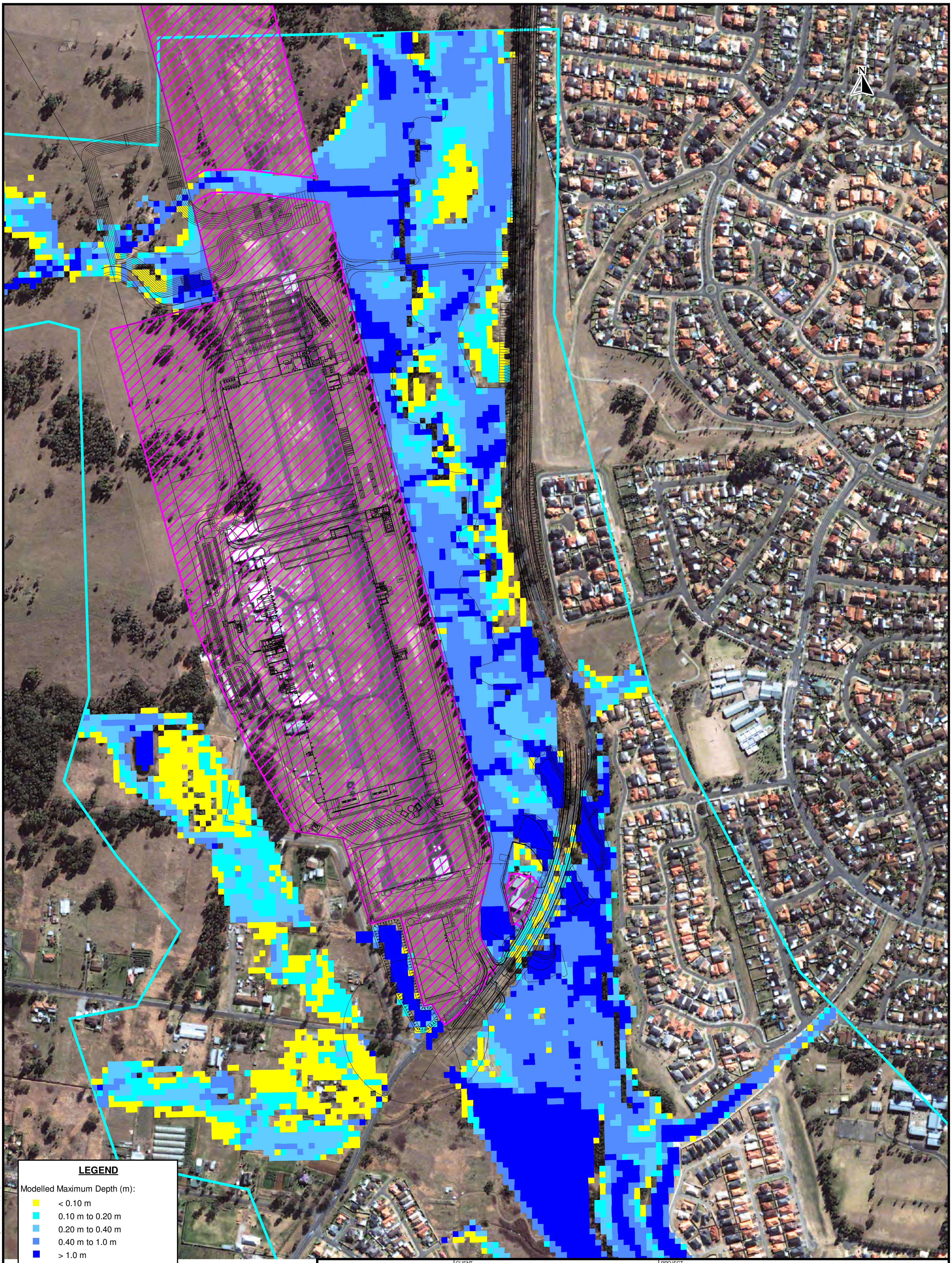

CLIENT: URS Australia Pty Ltd		PROJECT: FORMER HOXTON PARK AIRPORT SITE	
DRAWN: JRB	DATE: 25-03-10	TITLE: SIMULATION 1 - 100Y2H Maximum Flood Depth	
CHECKED: HR	DATE: 25-03-10		
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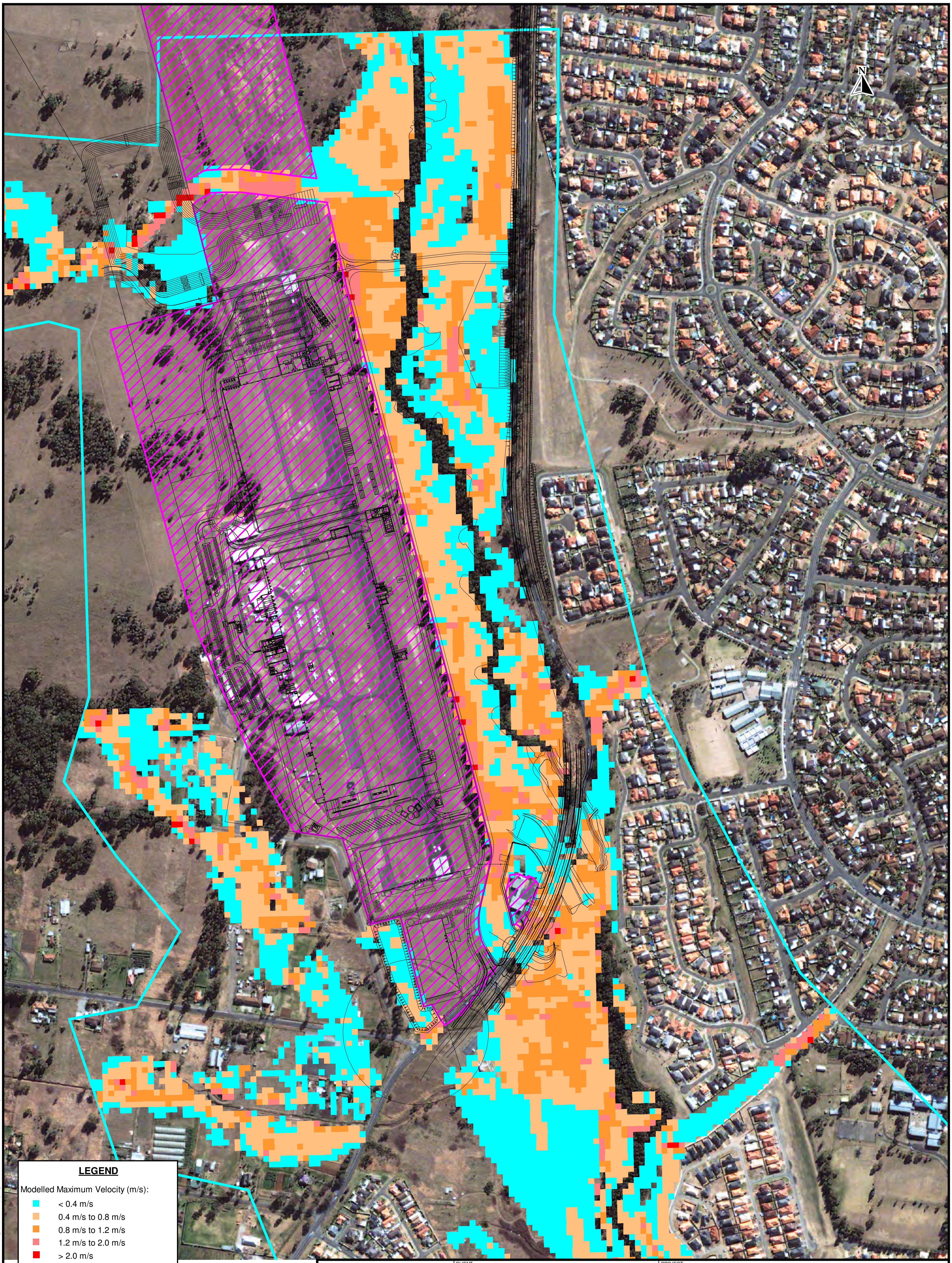

LEGEND

Modelled Maximum Velocity (m/s):

- < 0.4 m/s
- 0.4 m/s to 0.8 m/s
- 0.8 m/s to 1.2 m/s
- 1.2 m/s to 2.0 m/s
- > 2.0 m/s

General Items:

- Modelled Development Area
- Model Domain

Note: Datum GDA94, Projection MGA94Z56

CLIENT: URS Australia Pty Ltd		PROJECT: FORMER HOXTON PARK AIRPORT SITE	
DRAWN: JRB	DATE: 25-03-10	TITLE: SIMULATION 1 - 100Y2H Maximum Flood Velocity	
CHECKED: HR	DATE: 25-03-10		
SCALE: 1:6,000		PROJECT No: 107626023-001	FIGURE No: 11 · REV No: 0 · A3

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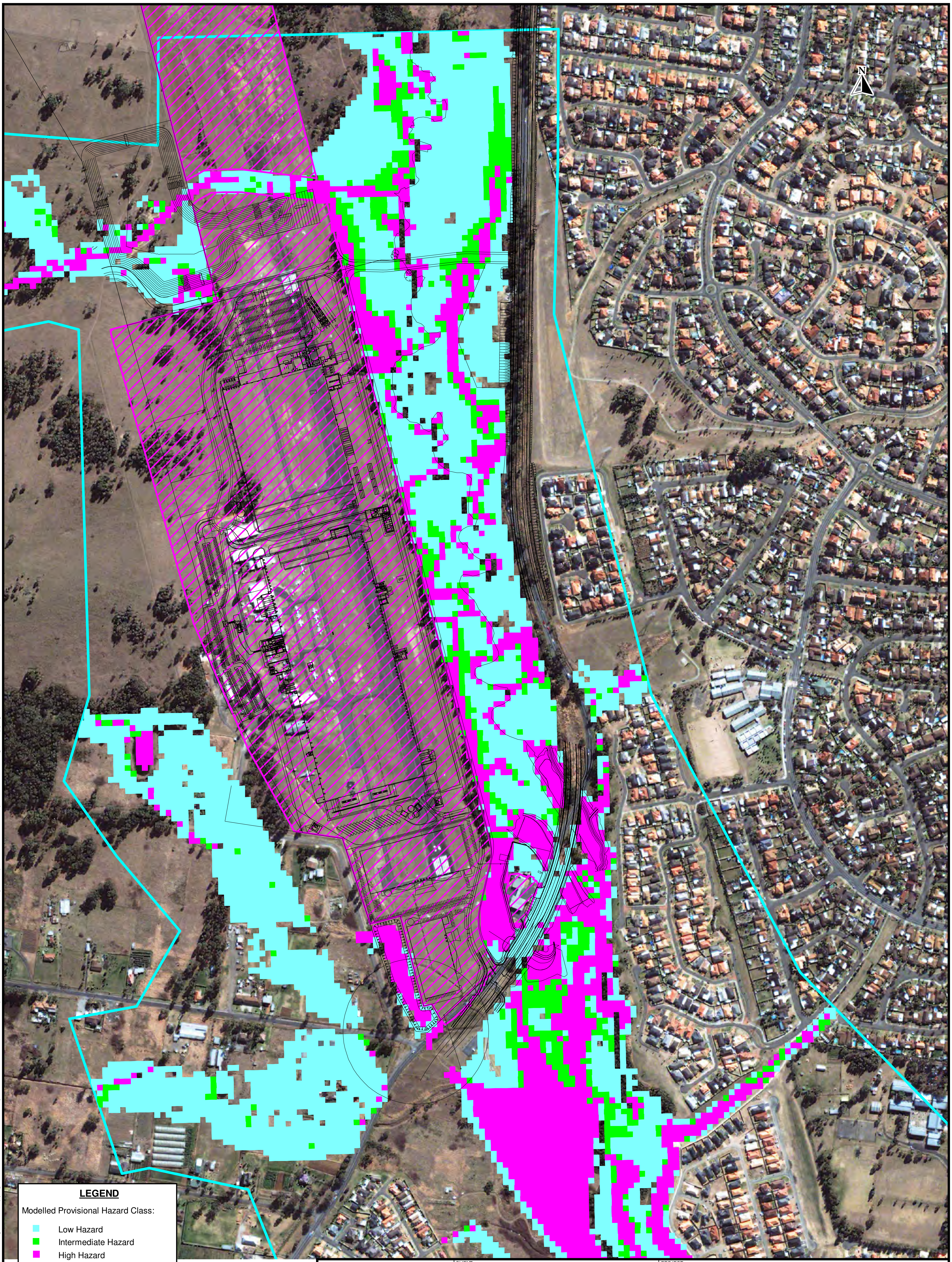

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CLIENT: URS Australia Pty Ltd		PROJECT: FORMER HOXTON PARK AIRPORT SITE	
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CHECKED: HR	DATE: 25-03-10		
SCALE: 1:6,000		PROJECT No: 107626023-001	FIGURE No: 12 REV No: 0 A3

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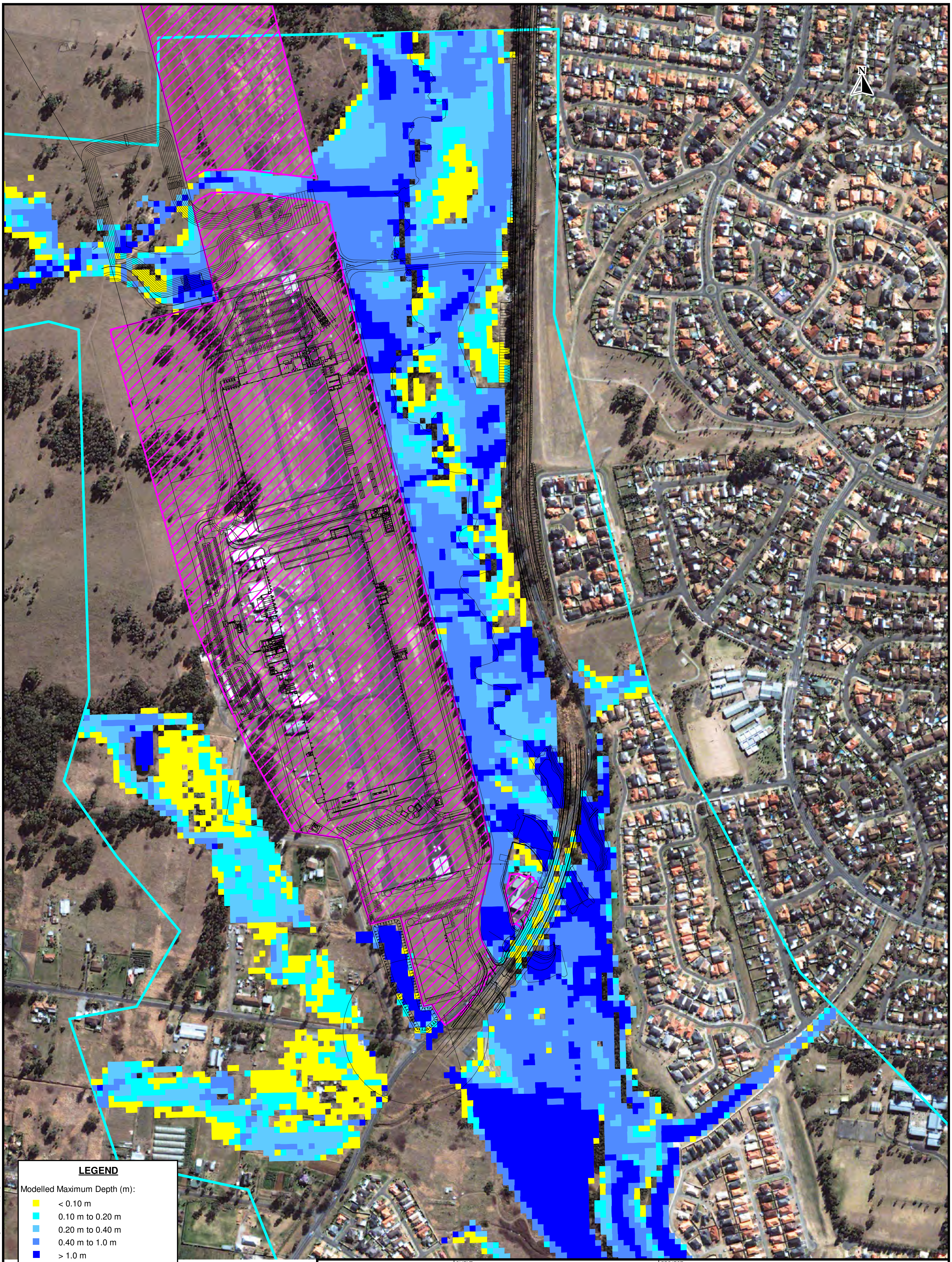

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CLIENT	URS Australia Pty Ltd		PROJECT	FORMER HOXTON PARK AIRPORT SITE	
DRAWN	JRB	DATE 25-03-10	TITLE	SIMULATION 2 - 100Y2H Maximum Flood Depth	
CHECKED	HR	DATE 25-03-10			
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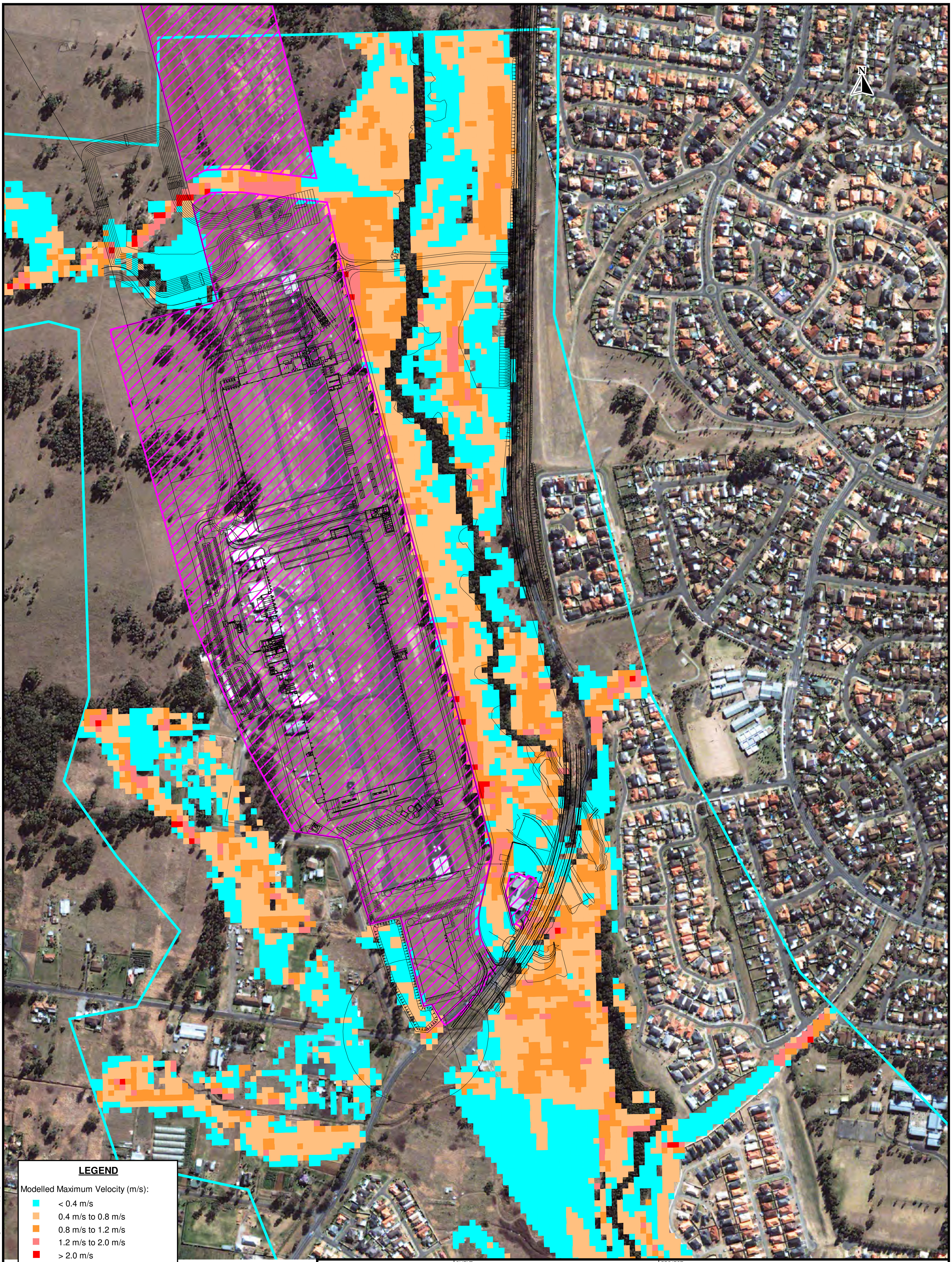

LEGEND

Modelled Maximum Velocity (m/s):
- < 0.4 m/s
- 0.4 m/s to 0.8 m/s
- 0.8 m/s to 1.2 m/s
- 1.2 m/s to 2.0 m/s
- > 2.0 m/s

General Items:
- Modelled Development Area
- Model Domain

Note: Datum GDA94, Projection MGA94Z56

CLIENT	URS Australia Pty Ltd	PROJECT	FORMER HOXTON PARK AIRPORT SITE
DRAWN	JRB	DATE	25-03-10
CHECKED	HR	DATE	25-03-10
TITLE	**SIMULATION 2 - 100Y2H Maximum Flood Velocity**		
SCALE	1:6,000	PROJECT No	107626023-001
FIGURE No	**14**	REV No	**0** A3

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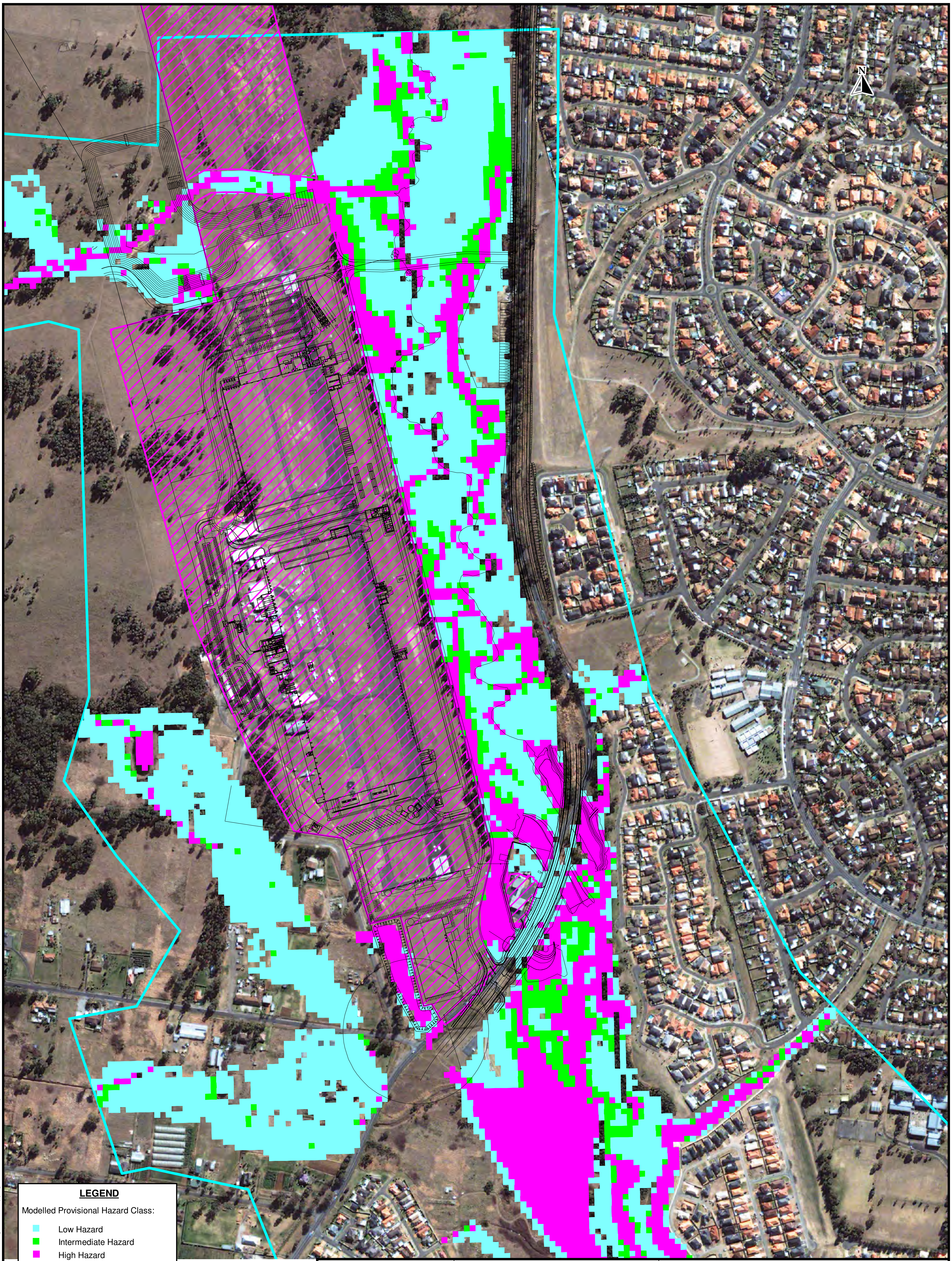

CLIENT	URS Australia Pty Ltd	PROJECT	FORMER HOXTON PARK AIRPORT SITE
DRAWN JRB	DATE 25-03-10	TITLE	**SIMULATION 2 - 100Y2H** **Maximum Hazard Class**
CHECKED HR	DATE 25-03-10		
SCALE	1:6,000	PROJECT No 107626023-001	FIGURE No **15** REV No **0** A3

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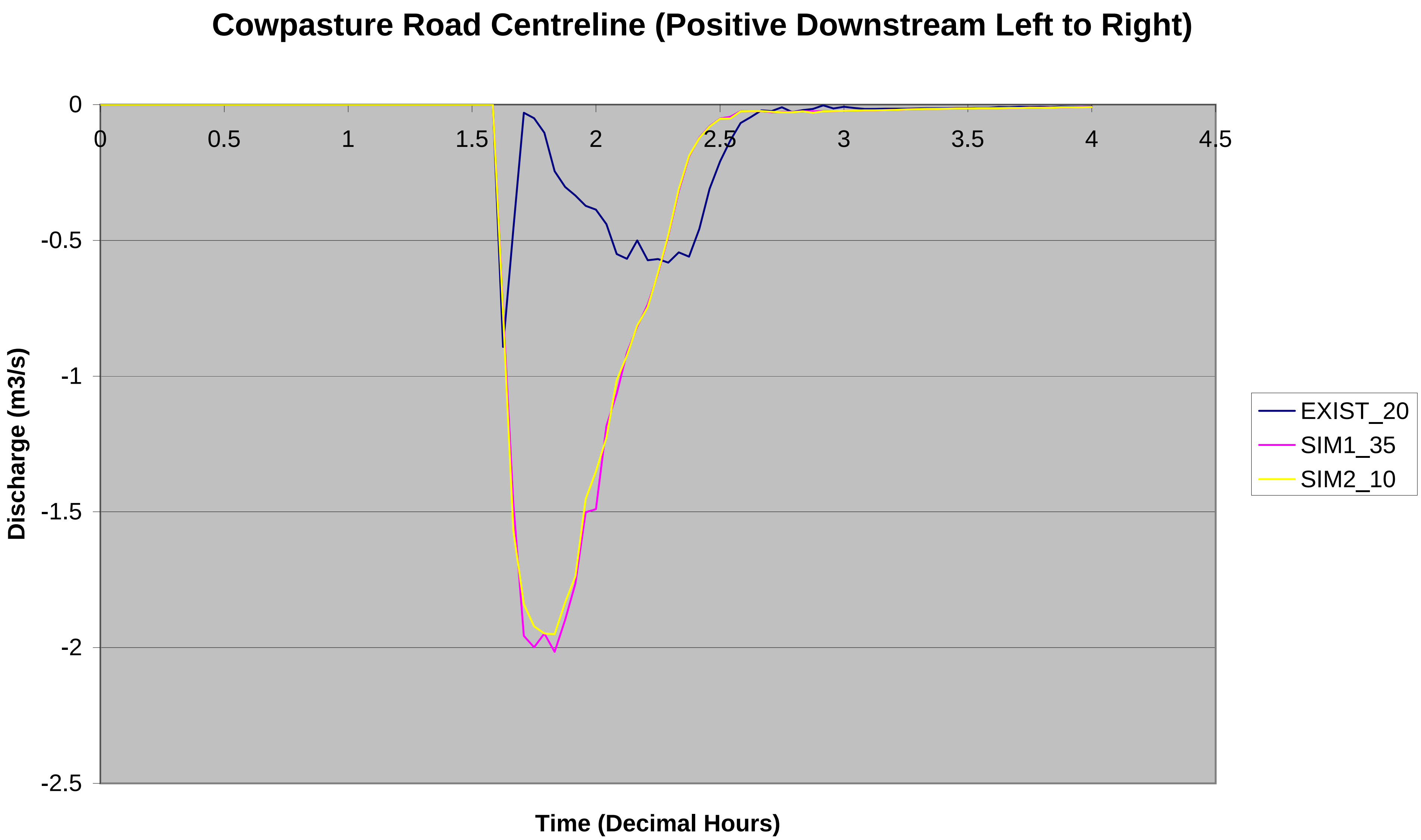
Appendix B Discharge Plots - 2D Flow over Cowpasture Road


Cowpasture Road Centreline (Positive Downstream Left to Right)
0
-0.5
-1
-1.5
-2
-2.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Discharge (m3/s)
Time (Decimal Hours)
EXIST_20
SIM1_35
SIM2_10

Appendix C Discharge Plots - 1D Flow under Cowpasture Road

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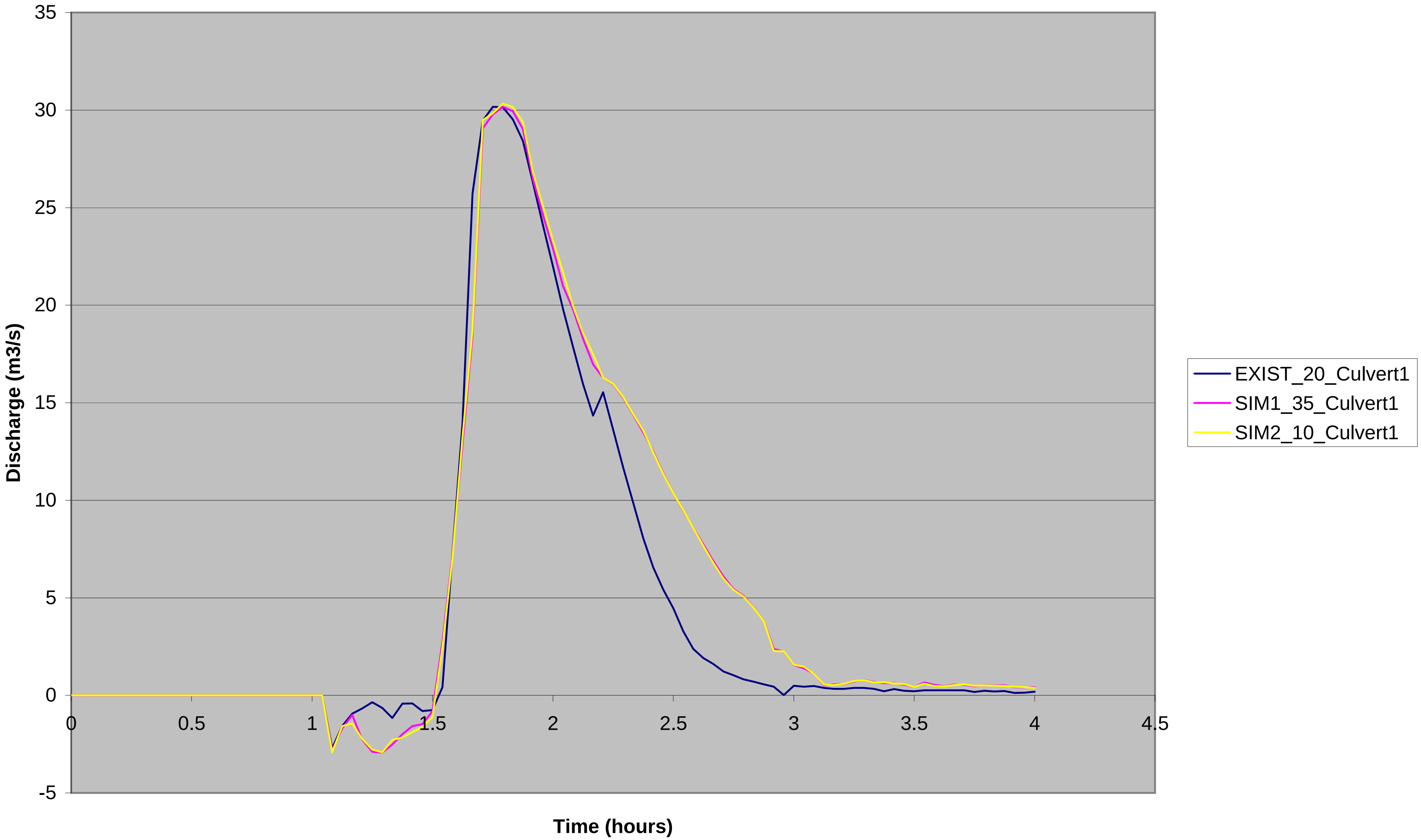

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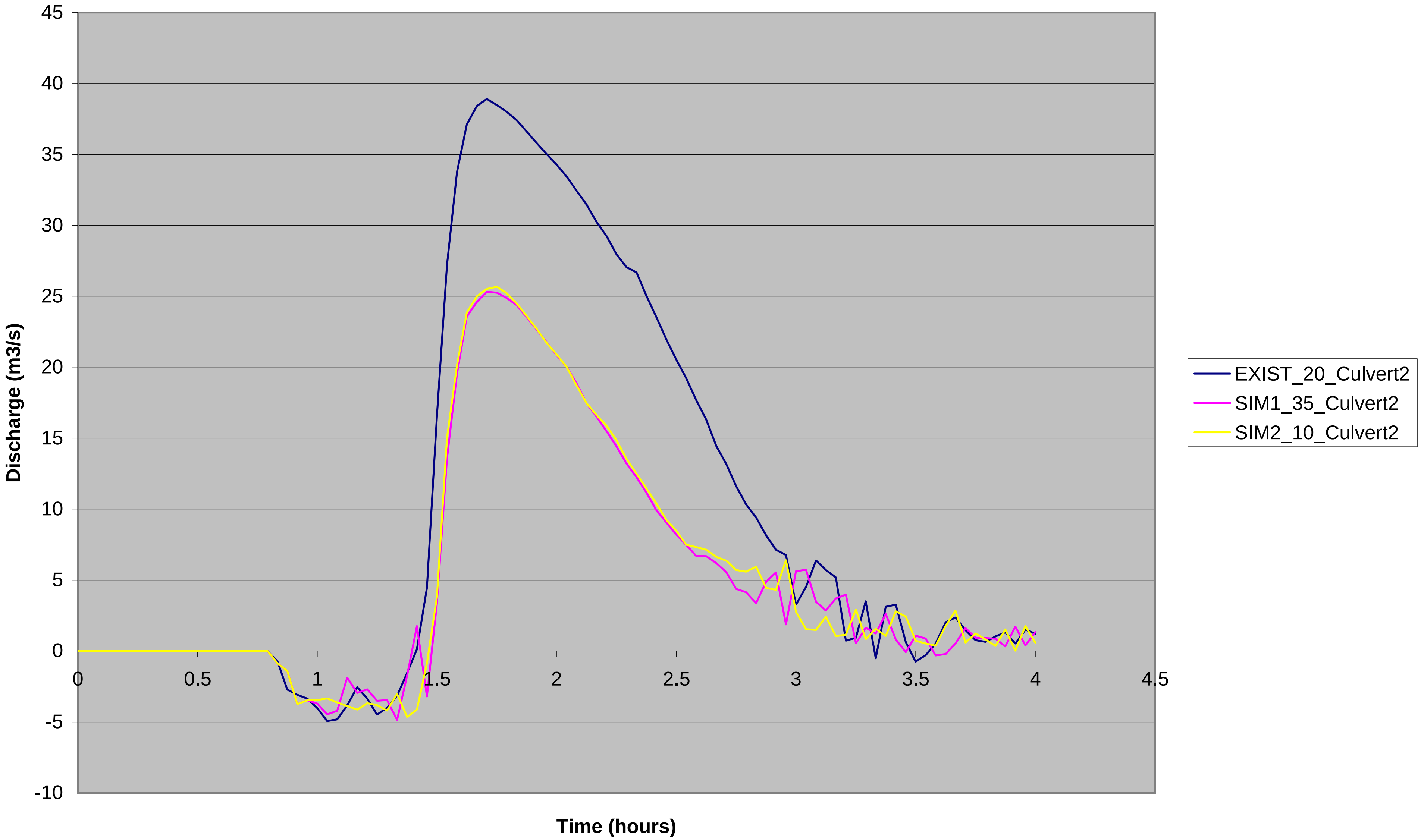

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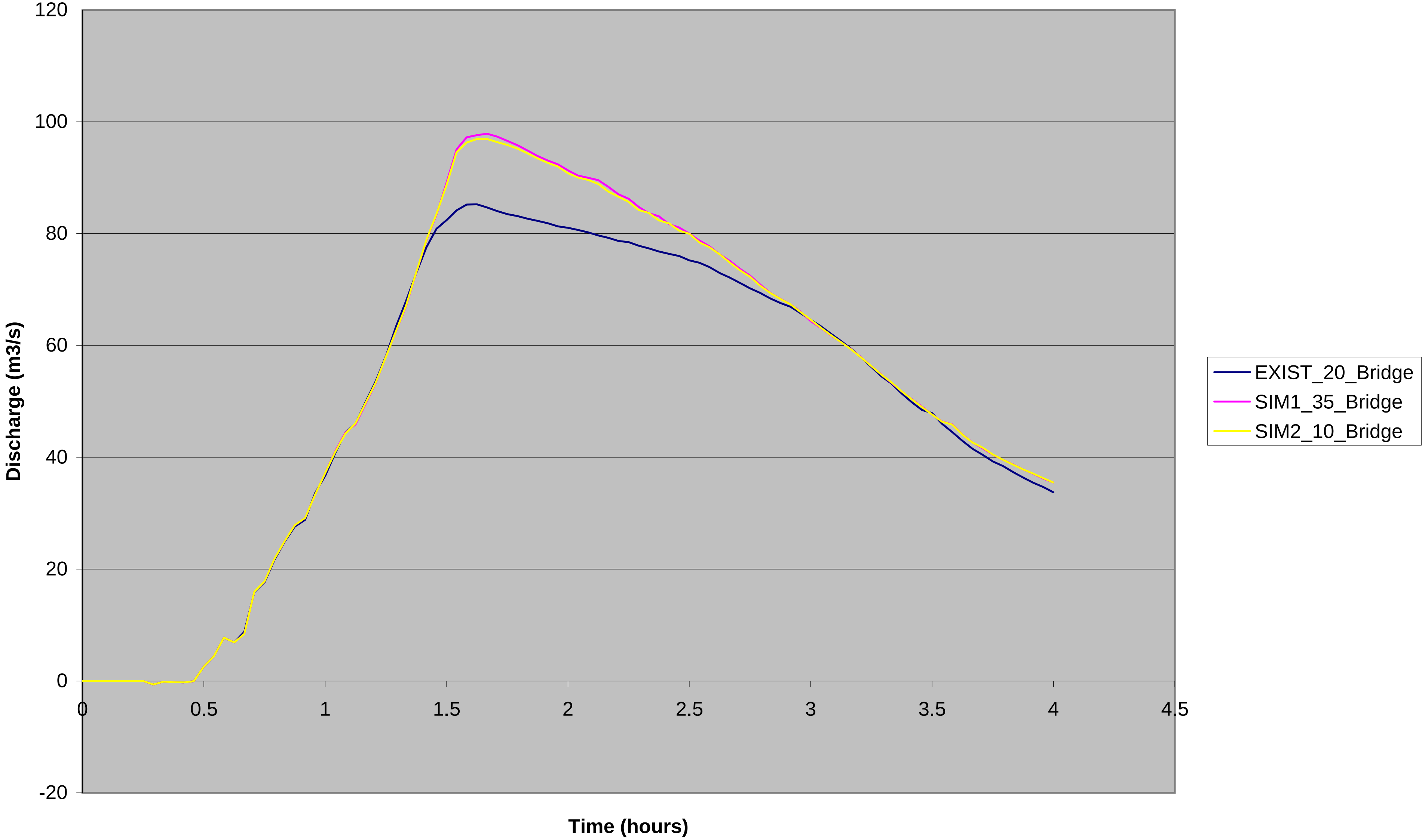

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