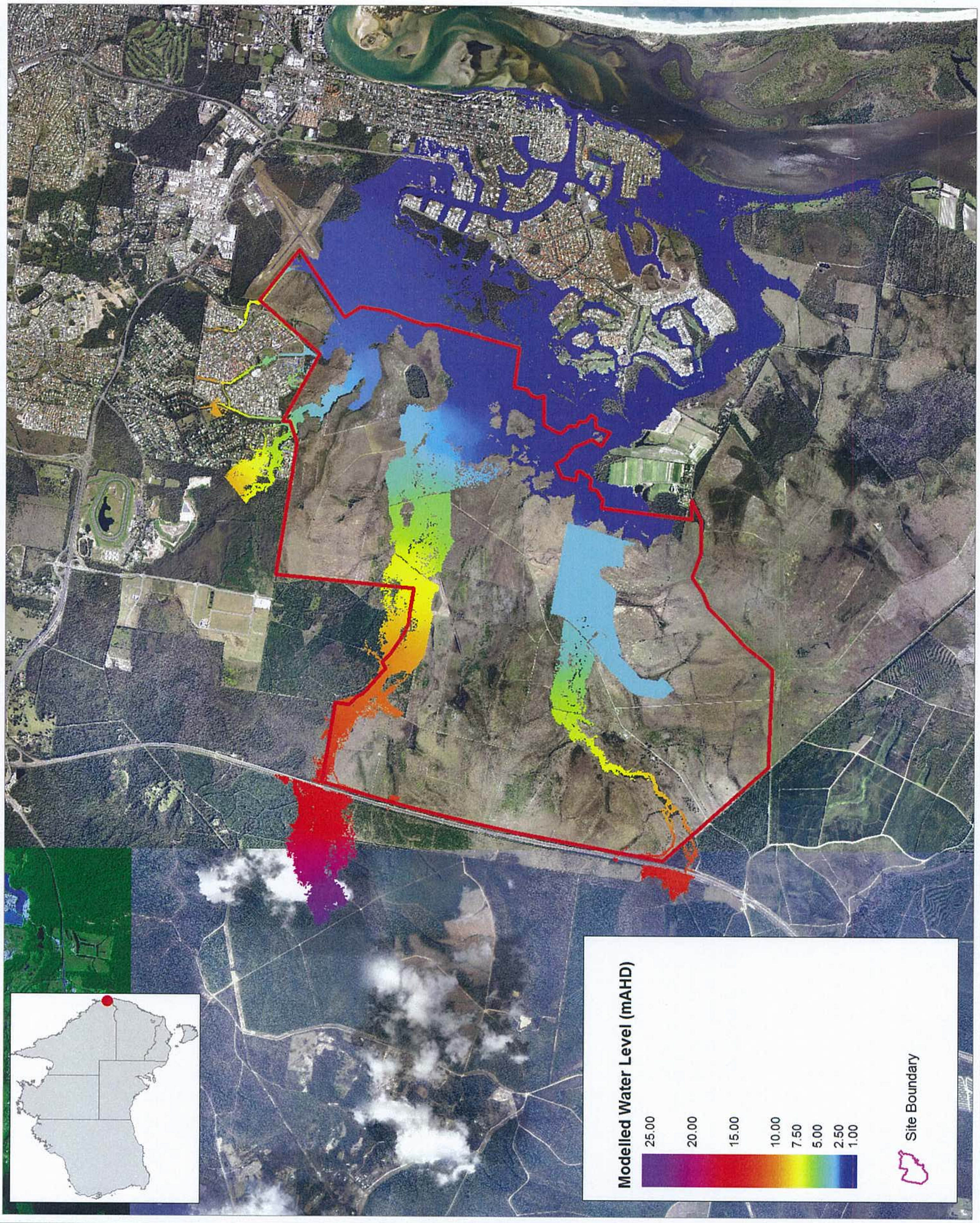

Title:

Q005 Peak Flood Levels For Developed Case

Figure: 3-22

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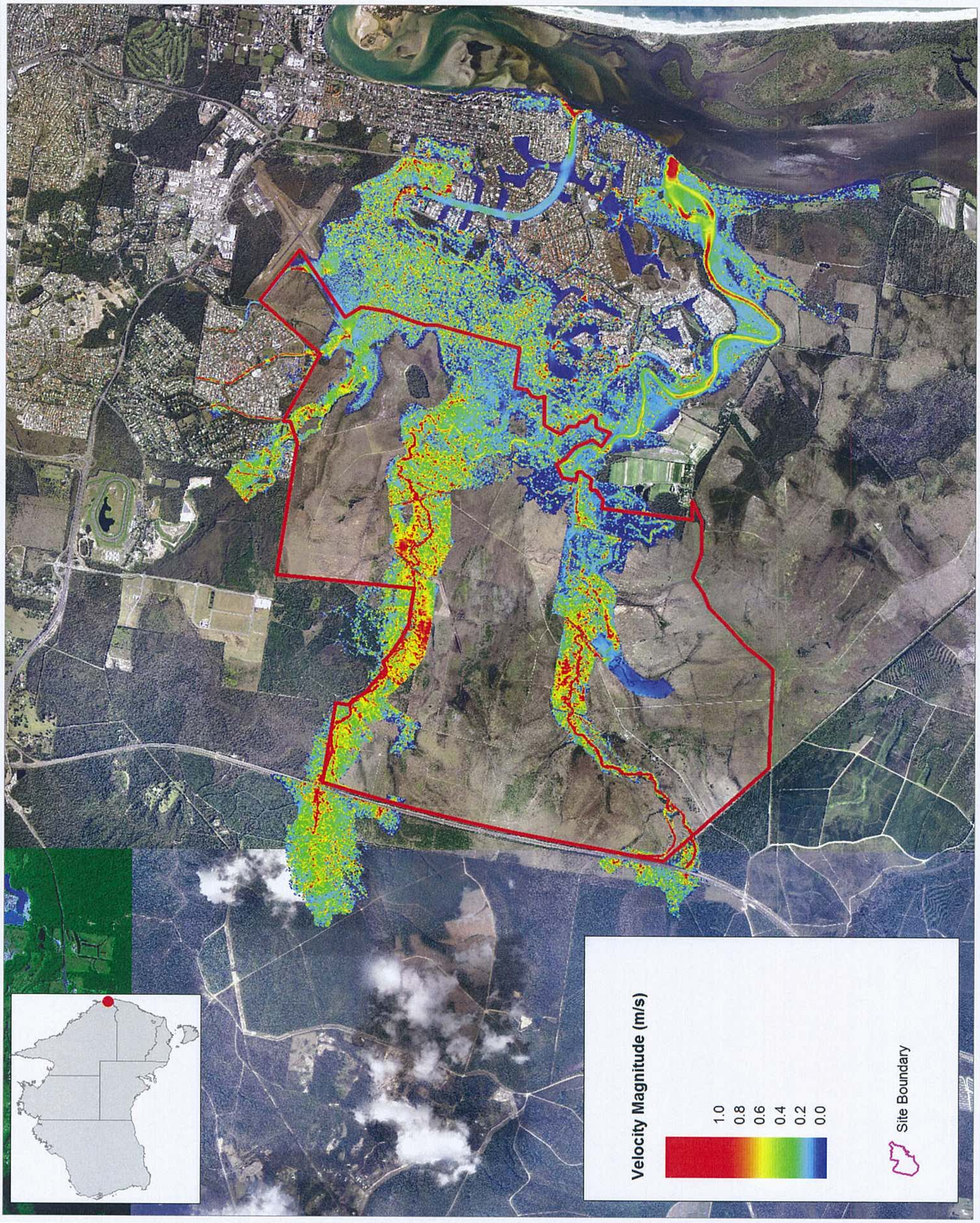

Title:

Q100 Peak Flow Velocities for Developed Case

Figure:

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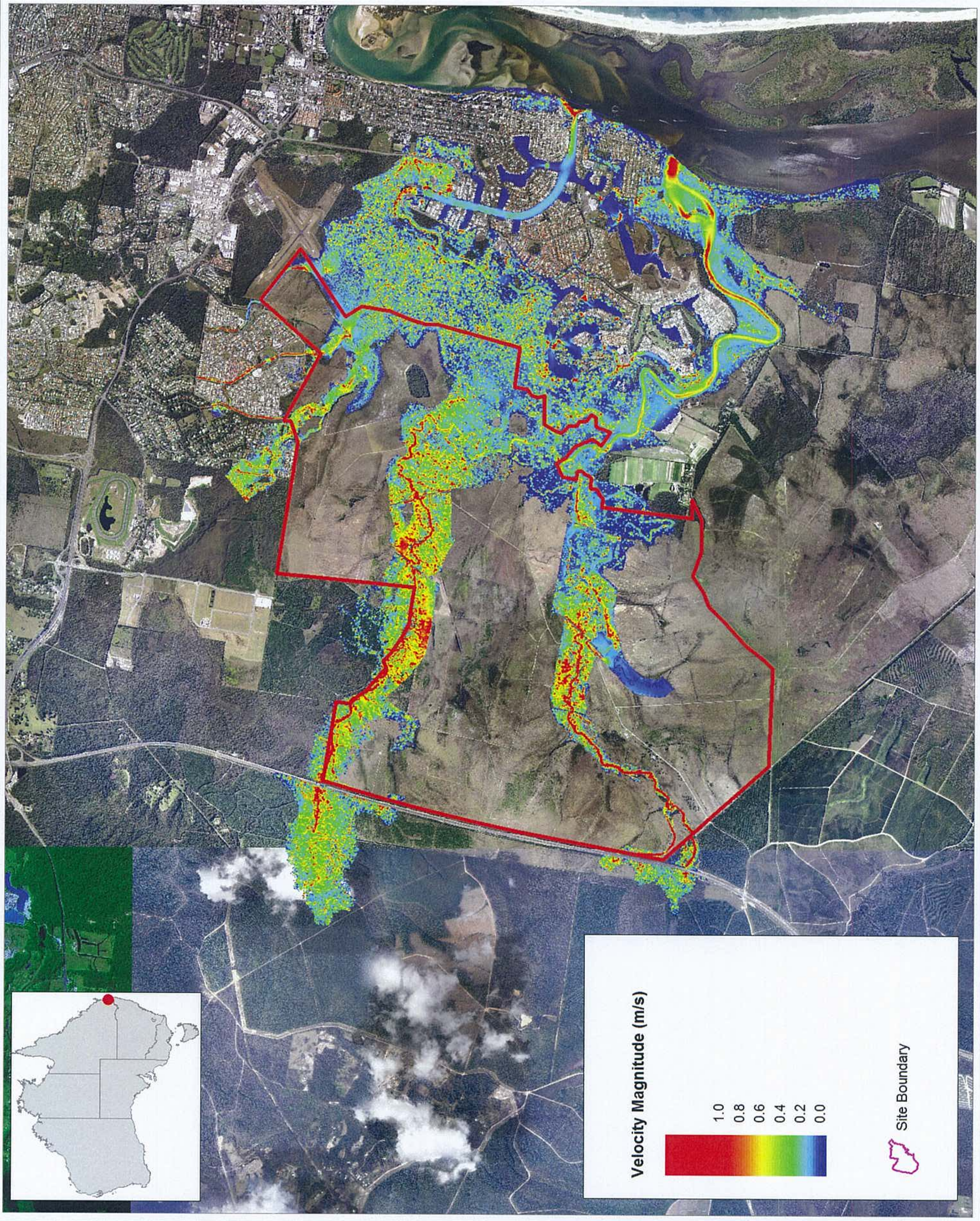

Title:
Q050 Peak Flow Velocities for Developed Case

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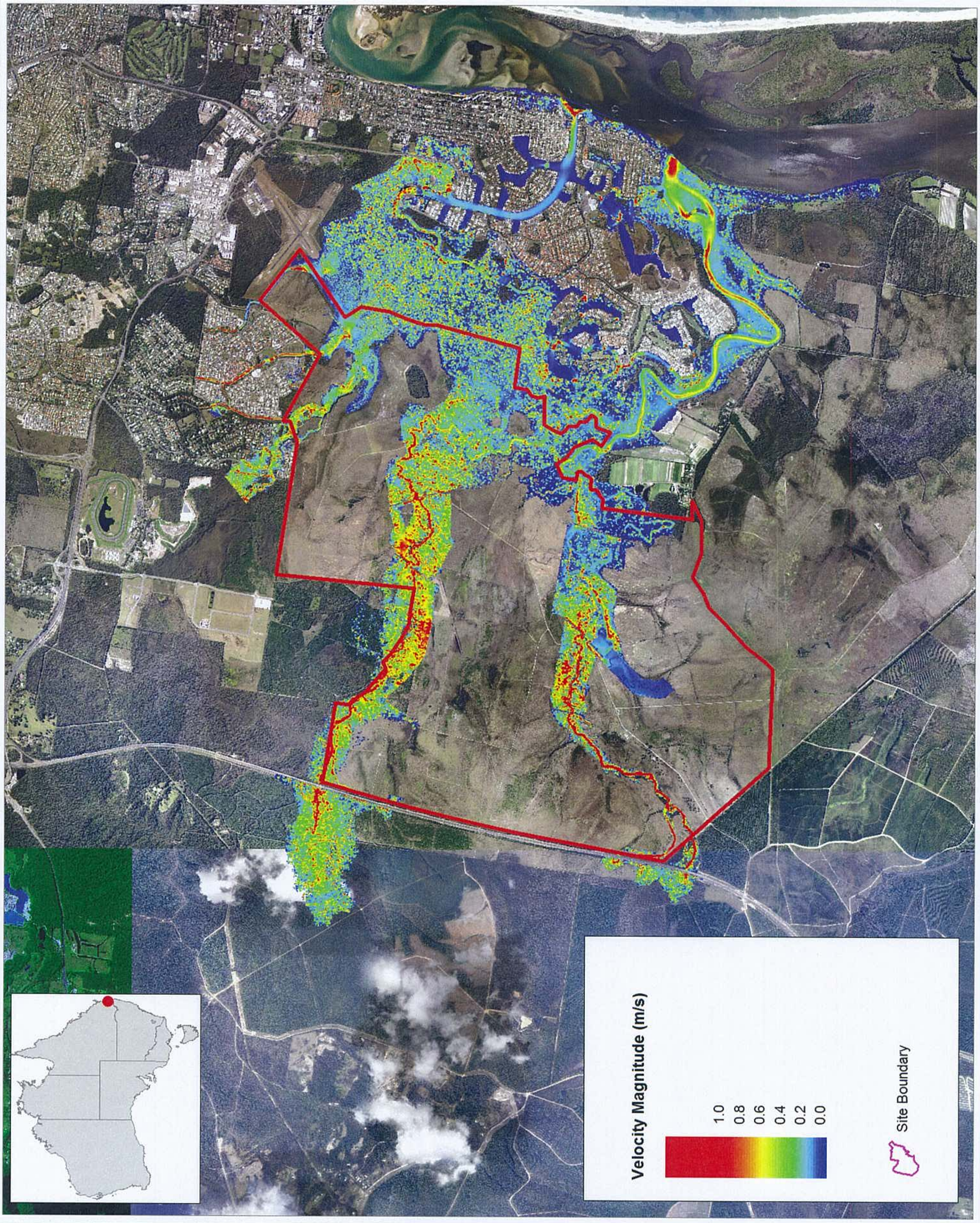

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Q020 Peak Flow Velocities for Developed Case

Figure: 3-25

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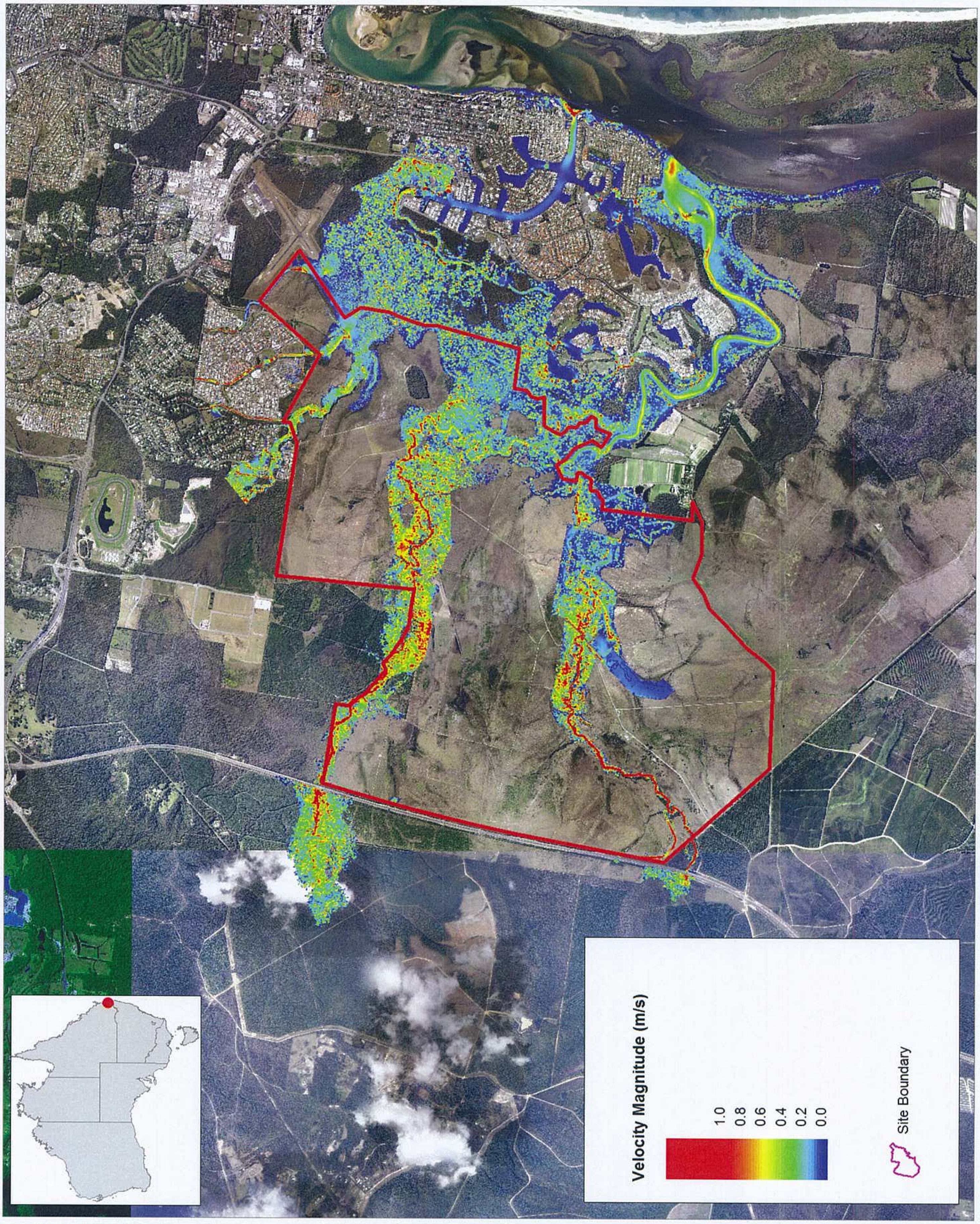

Title:
Q005 Peak Flow Velocities for Developed Case

Figure: 3-26

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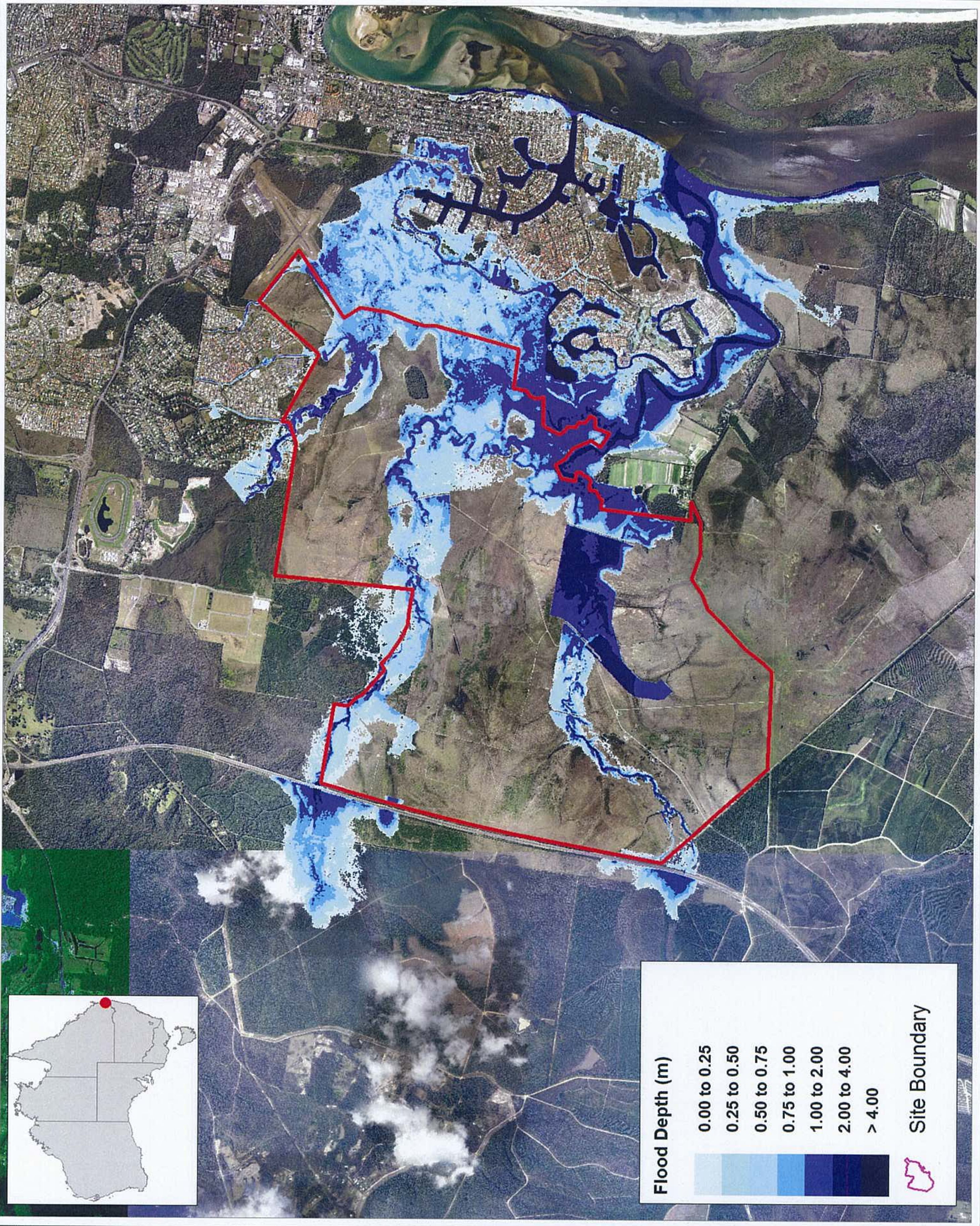

Title:

Q100 Peak Flood Depth For Developed Case

Figure: 3-27

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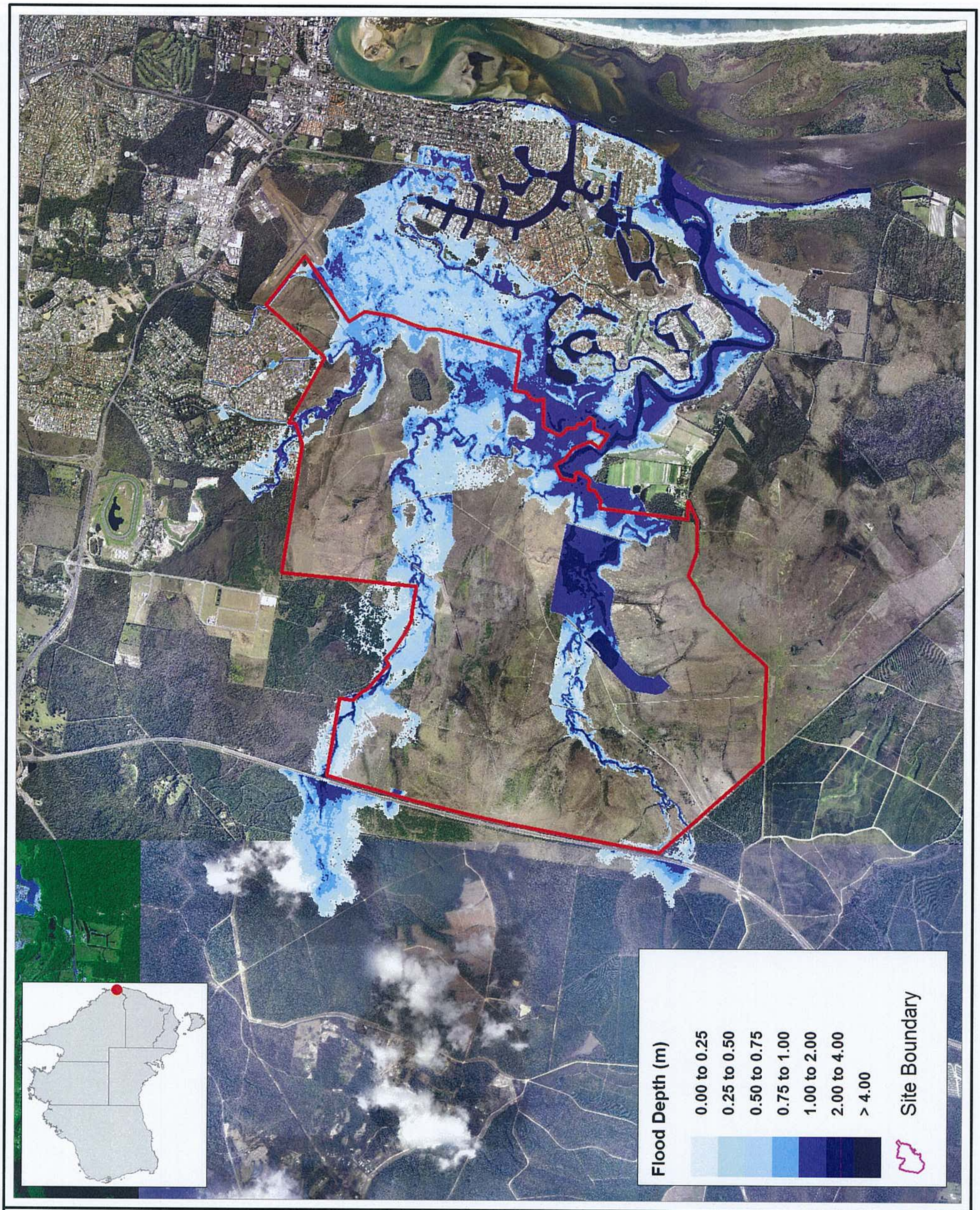

Title:

Q050 Peak Flood Depth For Developed Case

Figure: 3-28

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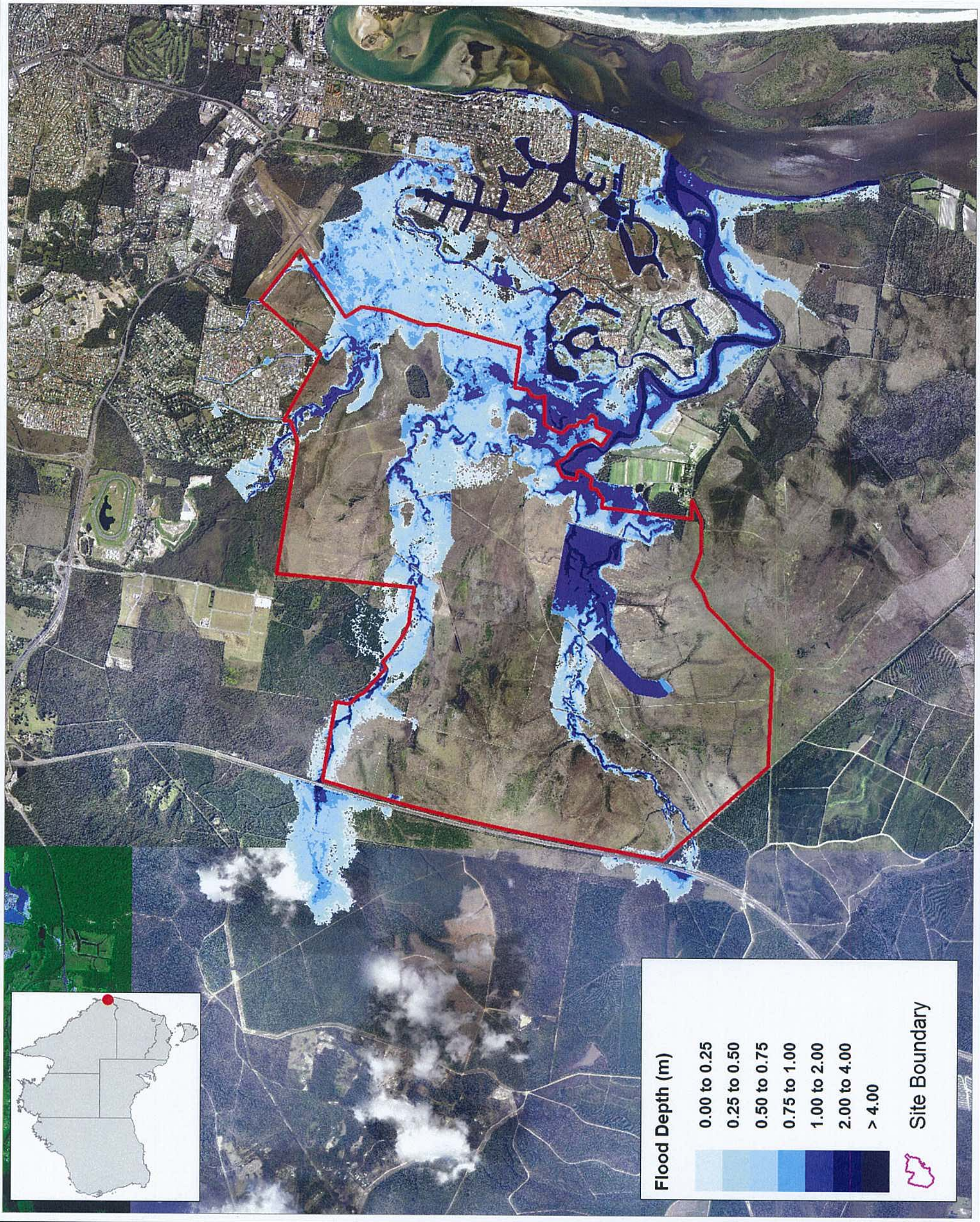

Title:

Q020 Peak Flood Depth For Developed Case

Figure: 3-29

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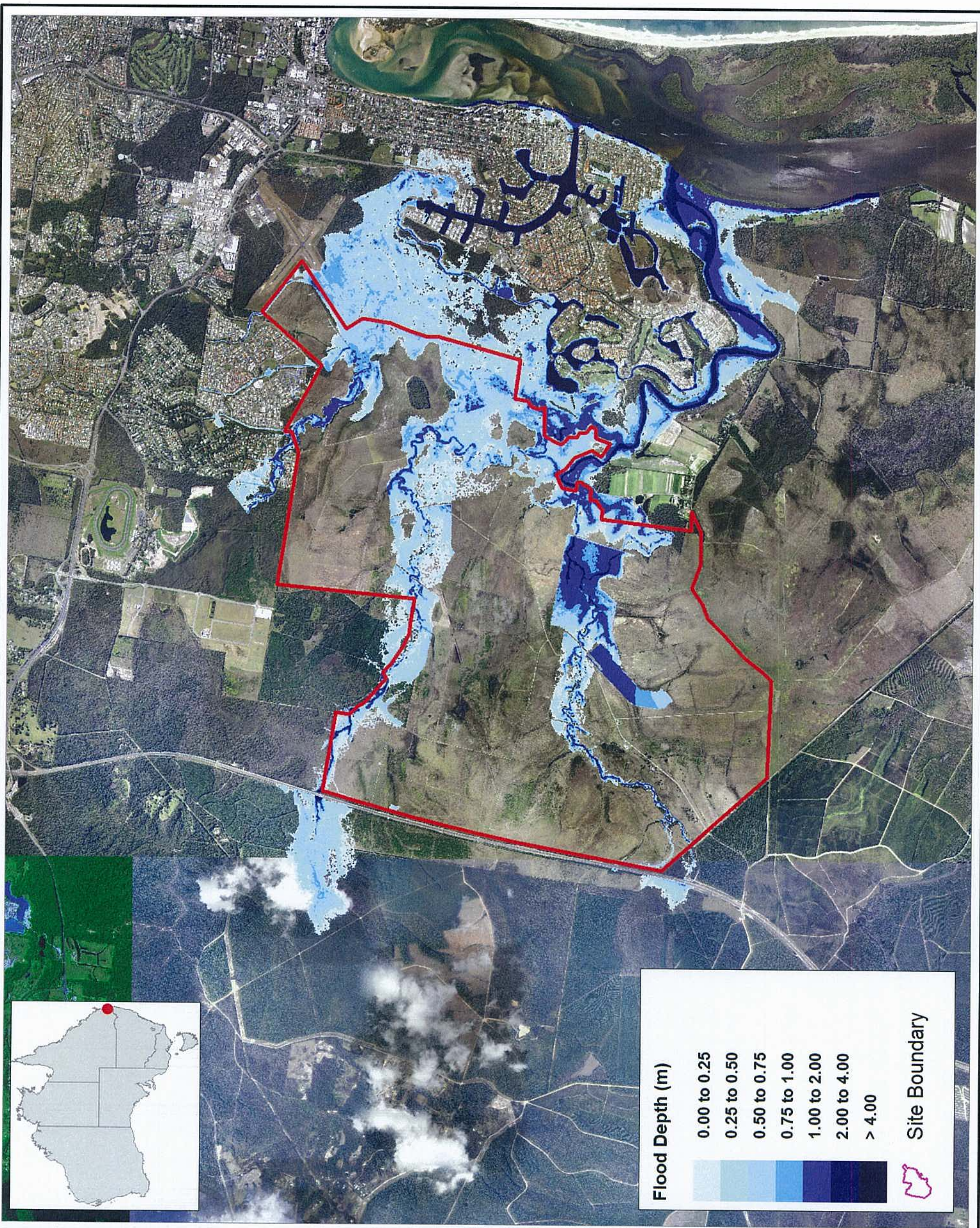

Title:
Q005 Peak Flood Depth For Developed Case

Figure: 3-30

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3.5 Flood Impact Assessment

3.5.1 Flood Impacts of Proposed Development

The TUFLOW model was iteratively adapted during this study to develop the proposed flood mitigation concepts. Three design flood magnitudes (5, 50 and 100 year ARI flood events) were then simulated with the development features outlined in Section 3.4.4.

Peak flood levels for the developed case were subsequently compared with those of the Base Case to derive flood impact maps. Figure 3-31 to Figure 3-33 show the impacts of the proposed works on the peak flood levels.

The flood modelling indicates that 100 year ARI peak flood levels in the areas adjacent to Pelican Waters will generally decrease by approximately 20mm to 50mm. There are generally no adverse flood impacts outside the UDA, apart from two areas:

- A small localised portion of rural land upstream of a drain on the Bruce Highway, which is owned by Stockland. This impact is caused by the assumed fill footprint that has been applied in the model blocking the natural flow path downstream of the drain through the site. However this flow path is along a proposed drainage path within the site, and the model assumptions therefore do not fully represent the intended flow behaviour in this area. These flood impacts will be revisited during the detailed design of the drainage through the site.
- The undeveloped floodplain on the left bank of Bells Creek North is showing some impacts in the order of 50mm to 100mm for the 100 year and 50 year events on land currently owned by Council. These impacts are largely due to restoration of the creek corridor, i.e. revegetation on the right bank of the creek, thereby increasing the hydraulic roughness and flood levels in the creek. The revegetation is viewed as a favourable activity that should not be discouraged by the depicted marginal impacts. Also, if the site was left undeveloped, this area would naturally revegetate over time. These impacts will be revisited during subsequent applications to ensure no adverse offsite impacts. Options may include additional priority flow paths.

In the low lying areas further to the east, where the peak flood levels are dictated by storm tide events, peak flood levels will be unaffected by the development.

Revegetation on Bells Creek North has increased flood levels by 20mm to 30mm at the downstream side of the culverts under the Bruce Highway on the edge of the UDA in the 100 year event. The Bruce Highway overtops in the base case. Since the road embankment controls flow across the highway, there is no impact on or upstream of the highway.

In the smaller flood events (1 year and 2 year), the model results predict a small flood impact in a creek in the wetland east of the UDA boundary. The depicted flood impact is smaller than the model can reliably predict in that area given the low flows and model design. Hence, this marginal impact is not considered significant and will be revisited during subsequent applications. The model results indicate that the proposed development causes peak 1 year flows in Bells Creek to reduce from $42m^3/s$ to $37m^3/s$.

3.5.2 Western Detention Basin

The use of a detention basin west of the highway on Bells Creek North, called the Western Detention Basin (WDB) has been investigated (see Figure 3-36) as an additional opportunity. This basin stores flood water entering the site on Bells Creek North, thereby reducing the peak flood flows on Bells Creek North. This benefits the flooding impact analysis, by:

- Further reducing flood risk on the Bruce Highway which currently overtops in the undeveloped case;
- Further reducing flood risk to downstream communities such as Pelican Waters;
- Improving flood storage capacity along Bells Creek North; and
- Providing a long term opportunity for stormwater harvesting.

3.5.3 Flood Impact Sensitivity Analysis

Sensitivity testing has been undertaken using the 100 year ARI flood event, focusing on an assessment of different design storm temporal patterns. The temporal patterns adopted for this study are from AR&R Zone 3 for a 6 hour and a 12 hour storm duration. In order to test the sensitivity of the flood strategy to a range of temporal patterns, a number of other storm durations were assessed. This was done by computing the flood impact for a range of storm durations, including the 3, 6, 12, 24 and 72 hours, each of which has a unique temporal pattern in AR&R. The peak water levels were derived by merging the peak water level results for the modelled storm durations and the ocean storm tide event for the pre and post development cases. Flood impact was then determined as the difference between the post and pre development case peak water levels.

Figure 3-37 presents the flood impacts from the storm durations assessed. The results are generally similar to the design case 100 year ARI flood impacts (Figure 3-31) which indicates that the proposed development has not increased flood risk beyond the site boundary.

3.5.4 Floodplain Storage

A comparison of floodplain storage in the vicinity of the proposed development has been undertaken on the 100 year peak flood depth results. The floodplain volume in the developed case is 40% higher than in the existing case. This indicates that the floodplain volume has increased due to higher flood levels within the developed area, caused by the detention basin on Bells Creek South and constrictions/crossings on Bells Creek North. Therefore, it is concluded that the proposed development has not reduced the floodplain storage capacity.

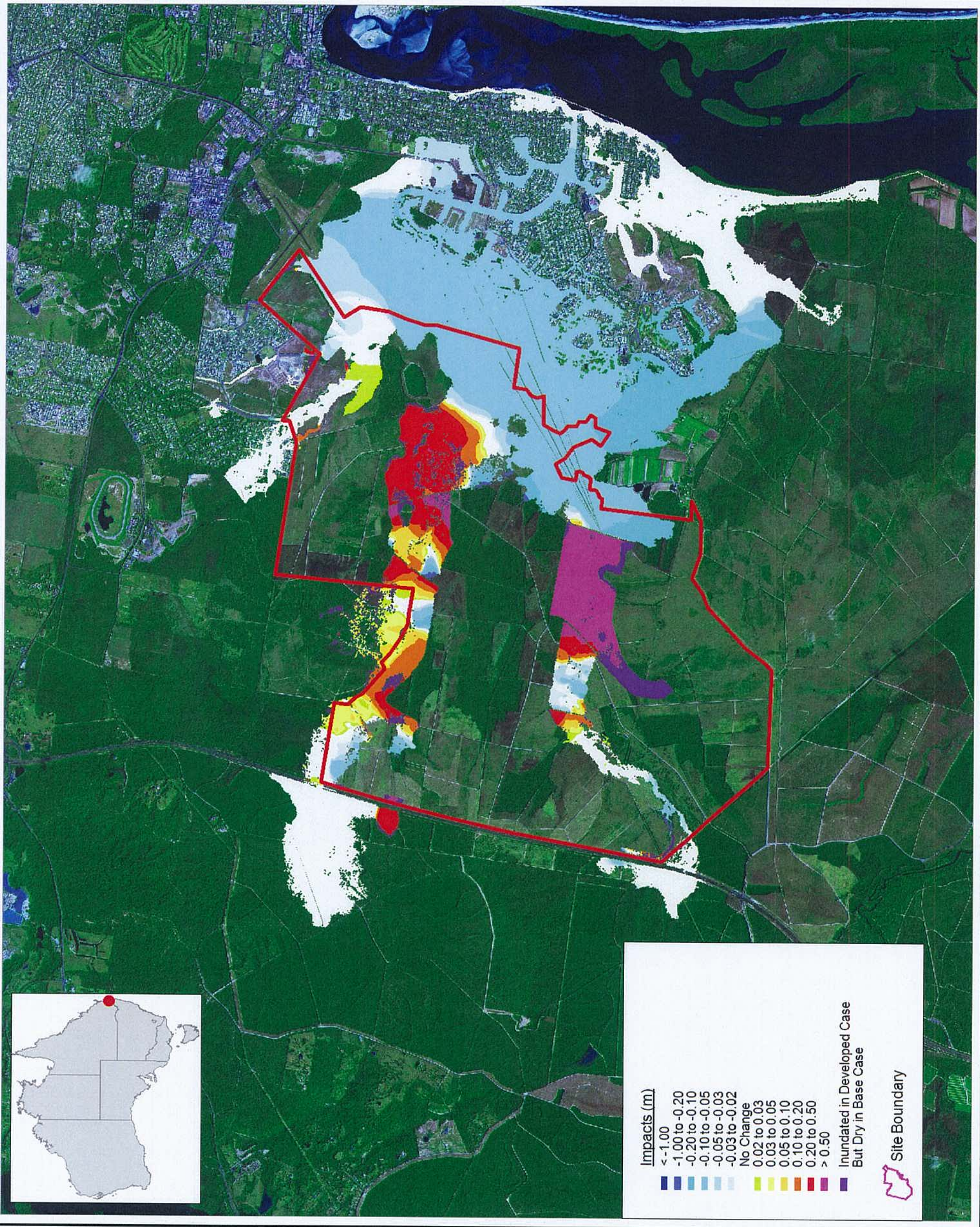
3.5.5 Conclusions

A flood impact assessment was undertaken in order to develop strategies to mitigate flood risk impacts outside the Caloundra South site boundaries. Minor alterations to the proposed land uses within the development footprint have taken place since the inception of this flooding assessment. These minor changes will not cause significant changes to the outcomes of this assessment. One such land use alteration is the inclusion of lakes. Lakes would be considered full at the start of a storm burst, and therefore have little consequence on the results of the flood modelling.

The flood risk impacts of the proposed development were assessed by comparing modelled peak flood levels of the developed case with the base case. For the impact assessment, five design flood magnitudes (1, 2, 5, 50 and 100 year ARI flood events) were simulated with the TUFLOW model.

Various development schemes have been investigated to derive a scheme that has no adverse flood impacts off site.

The modelling demonstrates that the potential impacts of the development can generally be mitigated through the implementation of a series of flood mitigation measures. A key component of the Flood Risk Management Strategy presented in this report is the provision of additional floodwater storage capacity at Bells Creek South through the implementation of hydraulic controls and lowering of the natural ground surface levels.



Title:

Q100 Peak Flood Level Impacts

Figure: **3-31**

Rev: **B**

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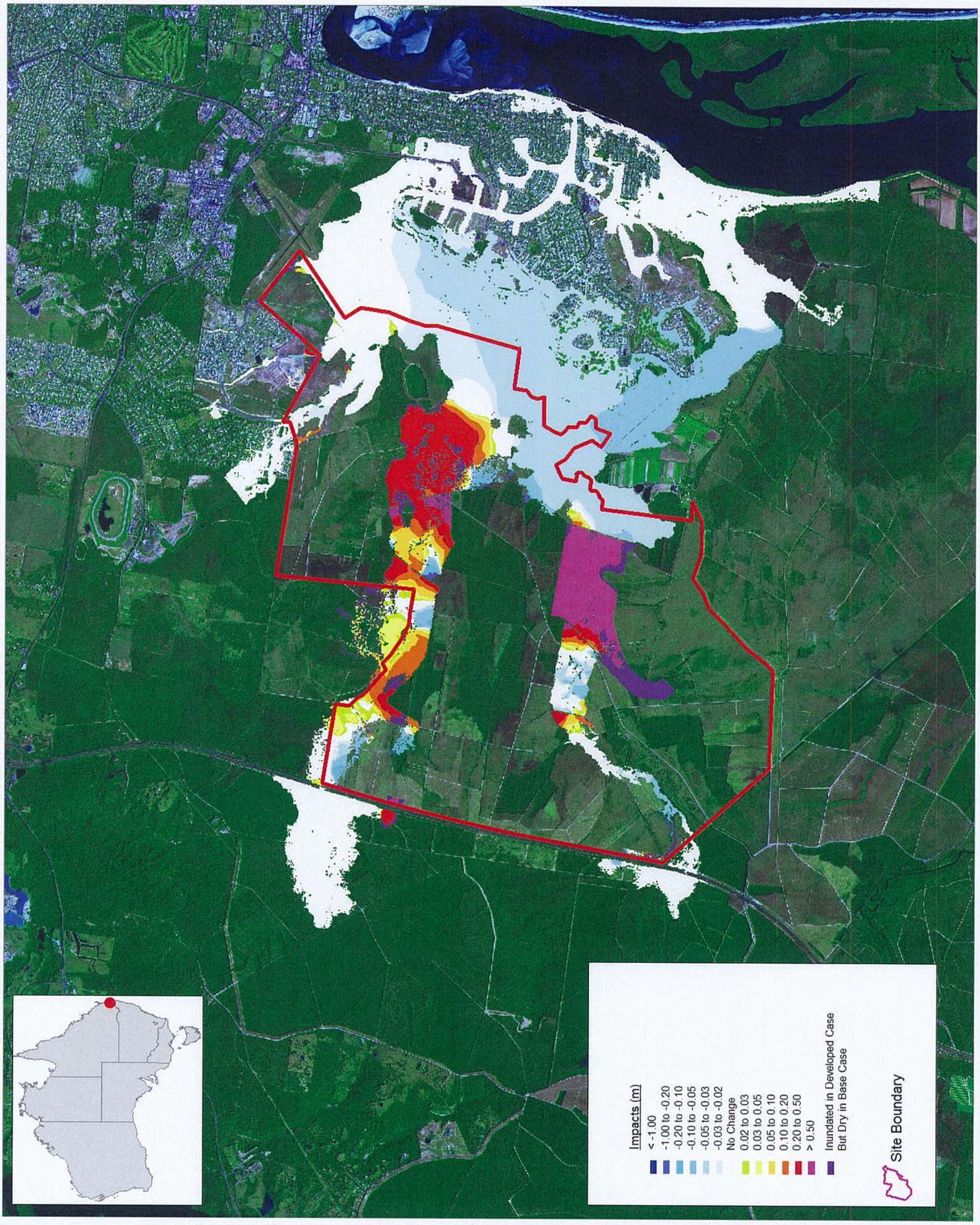

Title:

Q050 Peak Flood Level Impacts

Figure: **3-32**

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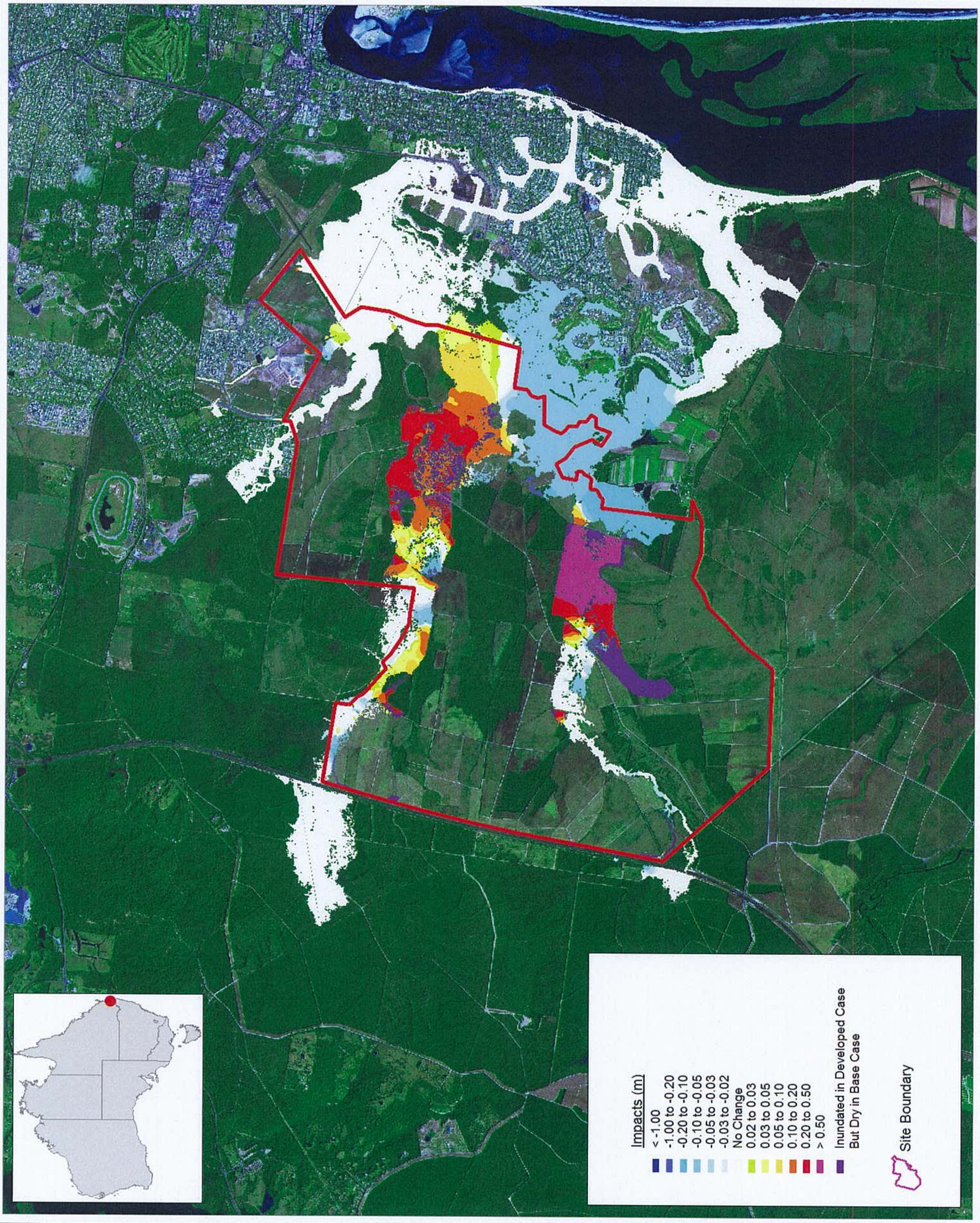

Title:

Q005 Peak Flood Level Impacts

Figure:

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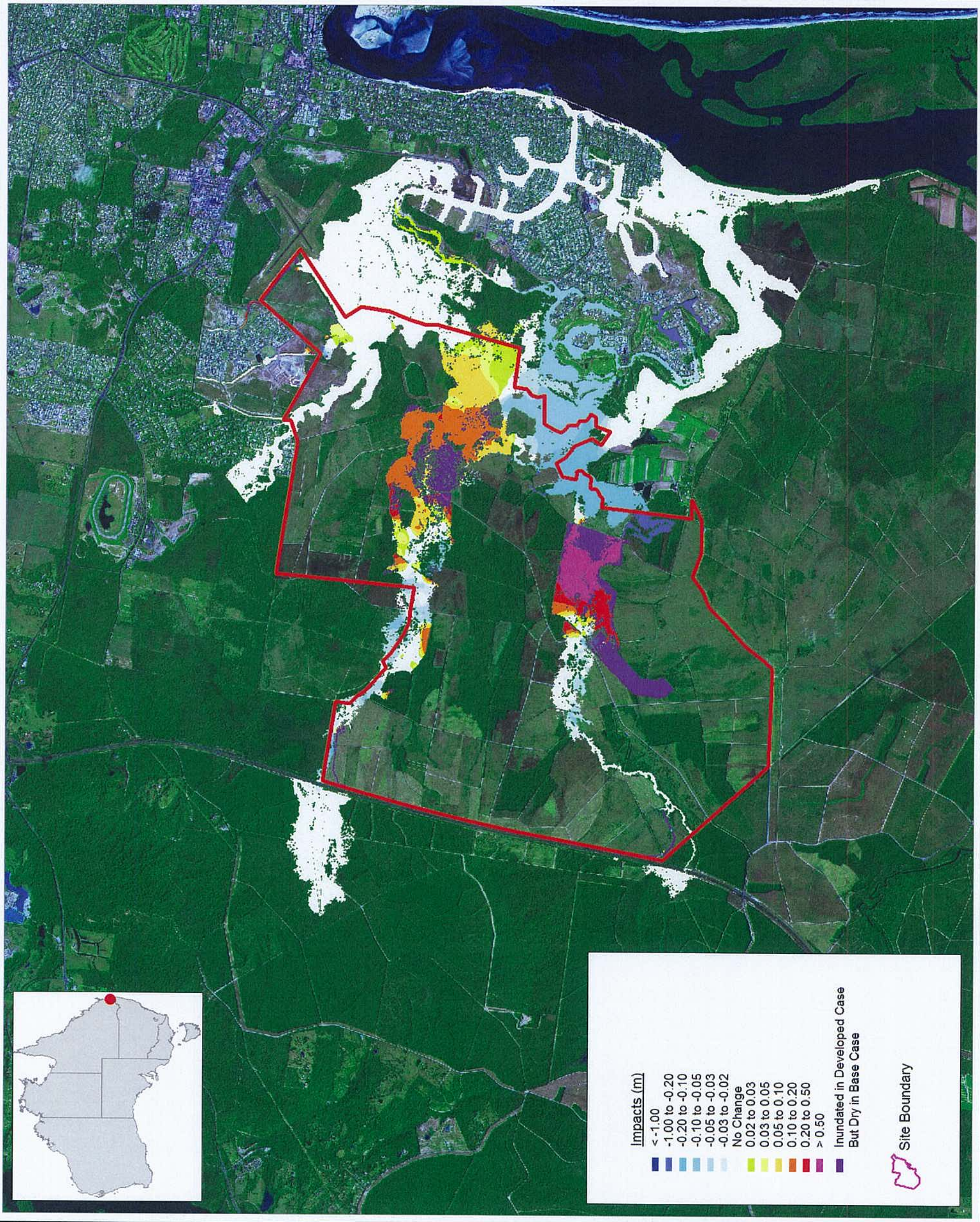

Title:

Q002 Peak Flood Level Impacts

Figure: **3-34**

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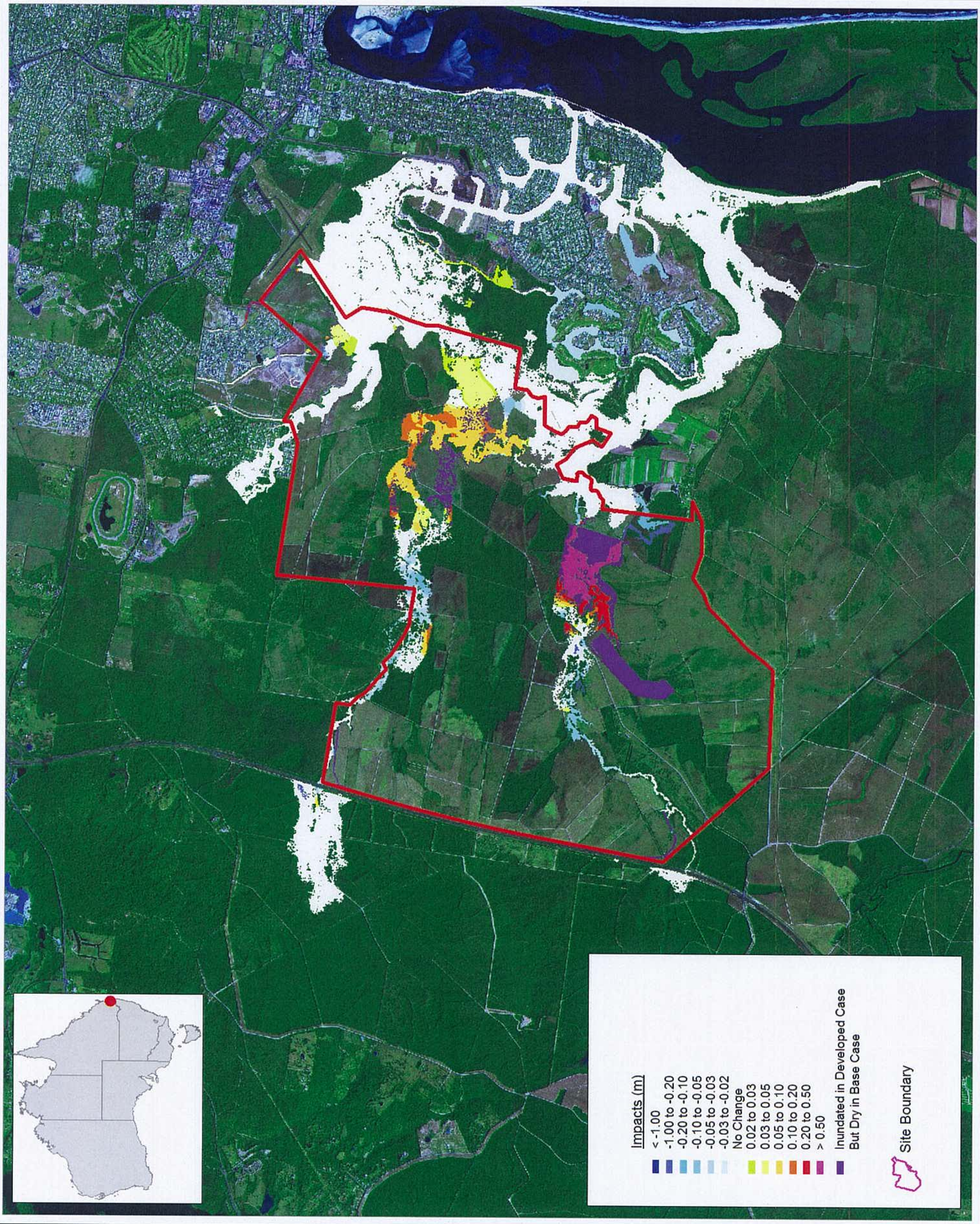

Title:

Q001 Peak Flood Level Impacts

Figure: 3-35

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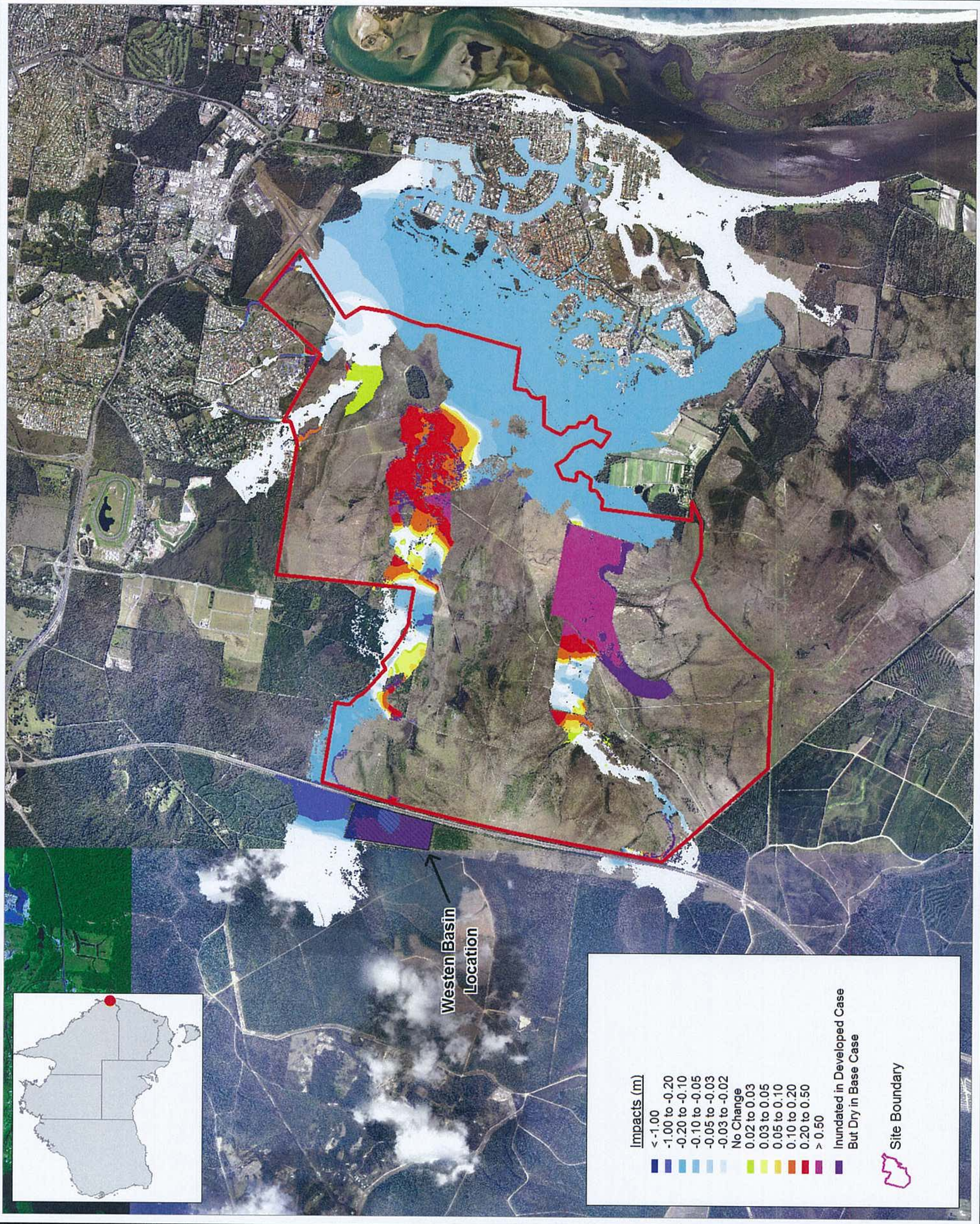

Title:

Indicative Q100 Peak Flood Level Impacts Western Basin Test Case

Figure: 3-36

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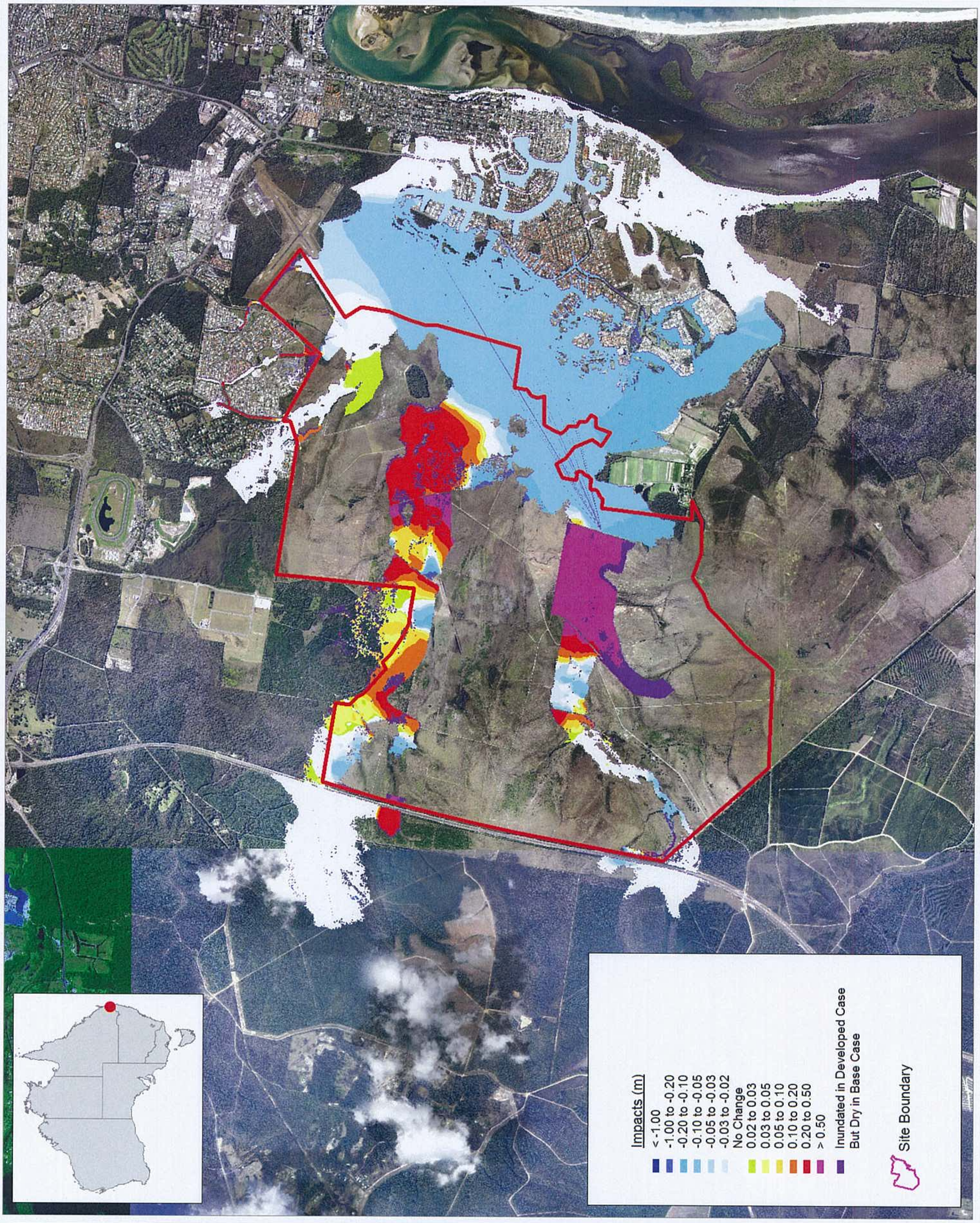

Title:

Q100 Flood Impact Sensitivity to Storm Duration

Figure: 3-37

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3.6 Climate Change Assessment and Flood Planning Levels

3.6.1 Introduction

To ensure that the proposed development has an appropriate flood immunity now and in the future, the ground elevations of the proposed urban areas (i.e. roads, commercial lots and residential allotments) will be set to a minimum level that incorporates an allowance for climate change impacts. This minimum level is referred to as the Flood Planning Level (FPL).

To assess how climate change impacts could affect the development, the potential impacts of climate change on the flood risk of the Caloundra South site have been assessed. For the climate change impact assessment, a planning horizon to the year 2100 has been adopted.

3.6.2 Potential Impacts of Climate Change

Current scientific research documented by the Intergovernmental Panel on Climate Change (IPCC), (IPCC, 2007) and the Department of Environment and Resource Management (DERM), (DERM, 2010) indicates future climate change resulting from global warming is likely to result in:

- Changes in extreme rainfall intensity;
- Sea level rise; and
- Changes to storm occurrences and storm wind intensity, affecting storm surge levels.

The predicted changes in extreme rainfall intensity, sea level rise and storm surge levels to the 2100 planning horizon have been documented below.

3.6.2.1 Extreme Rainfall Intensity

Rainfall intensity is likely to vary as a result of global warming. The most recent guidance on expected rainfall intensity increases in Queensland is discussed in *Increasing Queensland's resilience to inland flooding in a changing climate: Final report on the Inland Flooding Study* (Queensland Government, 2010). This report recommends that rainfall intensities are increased by 5% per degree increase in global mean temperature.

For the 2100 planning horizon timeframes, the predicted increase in global mean temperature is 4.0°C. Therefore, in the climate change assessment the design rainfall intensity utilised by the Caloundra South hydrology model was increased by 20%.

3.6.2.2 Future Sea Level Rise

Global-average temperatures increased at about 0.7 degrees Celsius since 1900 and the global-average sea-level has risen 1.7 mm per year since 1900 (Church and White, 2006). Due to anthropogenic greenhouse gas emissions the rates of both temperature increase and sea level rise are likely to be presently increasing and are expected to further accelerate in the future (IPCC, 2001; IPCC, 2007).

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) reports that global sea level rise is projected to be 18–59 cm by year 2100 relative to 1990 levels. These projections do not include a contribution from ice flow rates, however if these were to continue to grow linearly with global warming, then the upper ranges of sea level rise would increase by a further 10 to 20 cm (by year 2100 relative to 1990) (IPCC, 2007).

For planning purposes, an allowance of 0.8 m for global warming induced mean sea level rise is recommended. This allowance is consistent with recommendations by DERM and Policy 1.4 of the Draft State Planning Policy Coastal Protection. To assess potential climate change impacts, a mean sea level rise of 0.8m was adopted in this assessment.

3.6.2.3 Changes to Storm Occurrences and Storm Intensities

The potential impacts of increased frequency and intensity of tropical cyclones at Golden Beach due to climate change were investigated in the Oceans Hazard Assessment Stage 2 Report (JCU, 2004). The JCU study assessed the likely impact of a 10% increase in cyclone intensity and frequency including a poleward shift in cyclone track by 1.3 degrees. The JCU results indicate these changes to cyclone intensity, frequency and path may increase the 100 year ARI storm tide level around Bribie Island by approximately 0.15 m. This would be in addition to the mean sea level rise.

3.6.2.4 Summary

A climate change assessment has been undertaken for the Caloundra South development site. The assessment accounted for a predicted increase in extreme rainfall intensity, global and regional sea level rise, and changes to storm occurrences and storm intensities (storm surge). The values adopted, to represent to likely variation in these parameters to 2100, are outlined in Table 3-7.

Table 3-7 Recommended Climate Change Variation Estimates (Reference year 2100)

Environmental Forcing	Adopted Climate Change Variation Estimate
Extreme rainfall intensity / depth	+20%
Mean sea level rise	+0.80m
Increase in design storm tide levels [1]	+0.95m

3.6.3 Potential Impacts on Flood Risk

To establish the minimum ground elevations of the development, the flood impacts of the potential climate change variations have been determined on the basis of:

- Assessment of affected design storm tide levels; and
- Flood modelling of increased rainfall intensities.

3.6.3.1 Design Storm Tide Levels with Climate Change Allowance

The present-day 100 year ARI design storm tide level at Pumicestone Passage from Connell Wagner (2003) is 1.95 mAHD (also refer to SKM, 2006). The assessment of the potential climate change

[1] This increase includes 0.15m for increased storm occurrences and storm wind intensity and 0.80m for mean sea level rise

impacts has indicated that the 100 year ARI design storm tide level may increase by 0.95m to the year 2100 (approximately 0.15m due to changes to cyclone intensity, frequency and path and approximately 0.80m due to mean sea level rise).

For this, a 100 year ARI design storm tide level of 2.90mAHD for the year 2100 has been adopted for the Caloundra South development site. The adopted design storm tide levels are presented in Table 3-8.

Table 3-8 Adopted Design Storm Tide Levels including Climate Change Allowance

Average Recurrence Interval	Adopted Peak Storm Tide Level for 2100
5	2.68mAHD
50	2.88mAHD
100	2.90mAHD

3.6.3.2 Flood Modelling of Increased Rainfall Intensities

To investigate the impacts of increased extreme rainfall intensities due to climate change, the RAFTS-XP hydrological model was run with increased rainfall intensities. The design rainfall depths as determined by CRC-FORGE (refer to Table 3-3) were increased by an additional 20%.

The RAFTS-XP model results for the developed case with climate change allowance (refer to Table B-2 in Appendix B) suggest that the peak inflows may increase by about 25% on average as a result of climate change impacts.

The revised RAFTS-XP inflow hydrographs were then used as inflow boundaries in the TUFLOW model. In the simulations of the climate change scenarios (increased rainfall intensities), a constant water level of 1.25 mAHD was used as a downstream boundary condition. This water level represents a mean high water spring level at Pumicestone Passage in 2100.

3.6.3.3 Design Flood Levels with Recommended Allowances for Climate Change Impacts

The impacts of climate change on the design flood conditions around the site were assessed for the 100 year ARI for the post developed case. The peak flood levels of this climate change run is presented in Figure 3-26, the modelled peak flow velocities in Figure 3-27 and the modelled peak flood depths in Figure 3-28.

Figures 3-29 to 3-31 shows the modelled peak flood levels along the three creek channels that flow through the site (refer to Figure 3-32 for the long section locations).

The flood conditions in Figure 3-26 and Figure 3-28 were derived by compilation of a range of storm events, including the 6 hour and 12 hour duration freshwater flood events and storm tide events. The critical storm duration varies throughout the site with the shorter event critical in the upper part (Bells Creek North, Bells Creek South and Lamerough Creek) and storm tides critical in the low lying areas.

Figure 3-26 shows that the 100 year ARI peak flood level with climate change allowance varies from 18.6mAHD upstream of the Bruce Highway (Bells Creek North) to 2.0 mAHD at the southeast corner of the site.

The greatest increase in peak flood levels on site due to potential climate change will be experienced upstream of the Bruce Highway, where an increase of 0.74m is predicted directly upstream of culvert BH_36_037. Upstream of the other culverts the flood level increases will be significantly less.

In the low lying areas further to the east, where the peak flood levels are dictated by storm tide events, peak flood levels are predicted to increase by 0.95m in line with the climate change allowance for increase in design storm tide levels. Along the creeks on site, the peak flood level increases are generally smaller and typically are predicted to rise by between 0.1m and 0.2m.

3.6.4 Flood Planning Levels

It is recommended that the FPLs are set according to the flood levels presented in Figure 3-26, with an additional freeboard allowance. This will ensure that the proposed development has an appropriate flood immunity now and in the future.