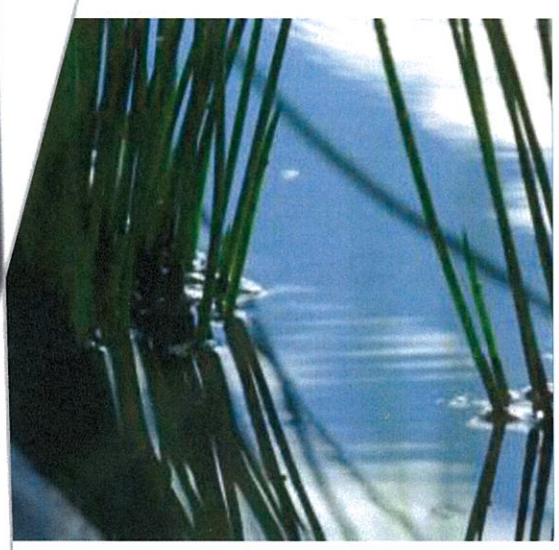
PLANS AND DOCUMENTS
referred to in the PDA APPROVAL
- 8 JUL 2015
MEDQ

# Flagstone City - Stage 7

## Stormwater Management Report

**7217/43/R11V1**



Prepared for
Peet Flagstone City Pty Ltd

14 January 2015

Cardno
Shaping the Future

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# 1 Introduction

This Stormwater Management Report (SMR) has been prepared by Cardno's Water Team who are specialist water quality, hydrologic and hydraulic consultants, for Peet Flagstone City Pty Ltd to investigate the stormwater management requirements for the Stage 7 of the Flagstone City development, located in Logan City Council (LCC) under the Department of State Development, Infrastructure and Planning (DSDIP). This report has been prepared as a supporting document to accompany the develop application for reconfiguring a lot.

The location of the Stage 7 and the Masterplan extent is shown on Figure 1. The current structure plan layout has been provided by RPS and is included in the reference section of this report. Additional detail of Context Area 1 and more specifically Stage 7 has also been provided by RPS and is included in the reference section of this report.

This report provides the detail of the stormwater quality management for Stage 7 in accordance with the framework defined in Cardno's '*Flagstone City – Masterplan Stormwater Management Strategy Report*' dated April 2014 (ref 721743/R10V5), and will minimise the adverse impact of development on the natural water cycle and protect the health of aquatic ecosystems. The key principles of Water Sensitive Urban Design are as follows:

- protect natural systems;
- integrate stormwater treatment into the landscape;
- protect water quality;
- reduce runoff and peak flows; and
- add value while minimising development costs.

This report also provides the management of the water quantity and site flooding for Stage 7, based on the approved Masterplan flood management solution. This masterplan solution presents an integrated approach to the flooding to provide the most cost effective solution both in terms of construction and on-going maintenance. The details of the flood management are contained in Cardno's '*Flagstone City – Masterplan - Flooding Assessment*' dated September 2014 (ref 721743/R1V6). The assessment detailed in this report will consider the impacts of the Stage 7 and the previously submitted Stage 1 SMR development and recommend any of the masterplan mitigation measures.

# 2 Purpose and Scope of the Report

The purpose of this report is to evaluate the stormwater management associated with the proposed Stage 7, and to demonstrate to DSDIP that an appropriate stormwater management strategy can be adopted.

A stormwater management plan (SWMP) has been appended to this report in Appendix A for possible inclusion in an overall environmental management plan (EMP). The stormwater management plan is a framework of reference to prevent adverse water quality impacts on the environment throughout the construction and operational phases of the development. The stormwater management plan specifically addresses the following elements and issues for both the construction and operational phases:

- Operational Policy (Objective);
- Performance Criteria;
- Responsibility;
- Implementation Strategy;
- Monitoring;
- Auditing;
- Reporting;
- Identification of incident or failure; and
- Corrective action;

In particular this report will detail measures to ensure:

- appropriate standards are maintained on all stormwater aspects within the site and that pollution control measures are operating and maintained;
- that the surrounding area is not adversely affected nor unduly disrupted by stormwater during construction, operations and maintenance; and
- there is a unified clear and concise plan for stormwater management throughout every step of the development process.

This report will be in effect throughout construction and until all operational conditions set out in the SWMP are met.

# 3 Existing Site and Proposed Development

## 3.1 Existing Site Description

The overall Flagstone City site is approximately 1500ha in area. It is located in an area bounded by the existing Brisbane to Sydney railway to the east, and forested property to the west. The Real Property description is

- Lot 1 on RP35155
- Lot 2 on RP47120
- Lot 4 on RP45728
- Lot 5 on S312569
- Lot 9 on S312569
- Lot 10 on SL6002
- Lot 873 on SP166448
- Lot 875 on SP146552
- Lot 907 on RP819216
- Lot 908 on RP819216
- Lot 910 on RP857850
- Lot 911 on RP857870
- Lot 988 on CP857841
- Lot 989 on RP854074

Parish of Mclean, County Stanley. The site currently does not have a street address but is located off Homestead Road, which connects to Teviot Road, Jimboomba.

The site is currently cleared rural land with vegetation maintained along the creeks and gullies that traverse the site. The site drains into Flagstone and Sandy Creeks, or tributaries of these creek systems. Within the site the elevations range from approximately 32.1m AHD to 170.9m AHD, with a predominate direction of flow in an easterly direction prior to discharging under the existing railway.

An aerial of the current site condition is presented on Figure 1.

## 3.2 Proposed Masterplan Description

Flagstone City is proposed to be a large master planned mix use development consisting of:

- Residential dwellings;
- Super allotments;
- Mixed use lots;
- Town Centre;
- Schools;
- Parks (including regional, district and local facilities); and
- Open Space.

The current structure plan layout and staging plan has been provided by RPS and is included in the reference section of this report.

## 3.3 Proposed East Commercial Description

Stage 7 covers an area of approximately 8 ha. As shown on RPS's Stage 7 layout, included in the reference section of this report, this area is to be developed and will likely consist of:

- Units and residential terrace home;
- Commercial buildings such as retail, supermarket , fast food and office; and
- Service Station.

The management of the stormwater will include the use of Bio-retention Systems for quality, local 1 year ARI basin for waterway stability, with no additional management required for regional flooding.

# 4 Performance Criteria

A number of objectives have been adopted for Flagstone City with respect to the management of flooding and stormwater quality. The framework of the stormwater quality management is presented in Cardno's '*Flagstone City – Masterplan Stormwater Management Strategy Report*' dated April 2014 (ref 721743/R10V5) and the flood management is presented in Cardno's '*Flagstone City – Masterplan - Flooding Assessment*' dated September 2014 (ref 721743/R1V6).

The criterion relating to the quality management for Stage 7 includes:

- protection of stream ecology and geomorphology from impacts of stormwater runoff; and
- adoption of Healthy Waterways '*Concept Design Guidelines for Water Sensitive Urban Design*' (2009) including:
  - Waterway Stability Management; and
  - Stormwater Management.

Healthy Waterways' guidelines (2009) were considered to provide best practice design criteria for the treatment of runoff from the developed areas. The objectives of relevance to stormwater quality are therefore:

- **Waterway Stability Management** - Limit the post developed peak one year ARI event discharge to the pre-developed ARI event discharge; and
- **Stormwater Management** - reduction in pollutant loads:
  - 80% reduction in sediment load;
  - 60% reduction in total phosphorus load;
  - 45% reduction in total nitrogen load; and
  - 90% reduction in gross pollutant load.

The criterion relating to the flood management for Stage 7 includes:

- Adopting the practice of maintaining all future development outside the main floodplain. This will maintain the flood storage within the catchment and river system, whilst also maintaining the ecological characteristics of the creeks and significant tributaries.
- Utilising on-line flood attenuation devices. The mitigation is achieved by providing restricted openings at all future road crossings. There is no additional excavation of the floodplain. This strategy causes a localised raising of flood levels upstream of the crossings with the benefit of reduced flood levels external to and downstream of the site.

The use of this strategy is considered an appropriate approach for a master planned community, with benefits of reduced assets and maintenance requirements, whilst still achieving appropriate flood management. This strategy will be supported by local detention basins located as necessary to meet the required performance criteria.

# 5 Data

The assessments detailed in this report are based on the following data:

- Aerial LiDAR survey data obtained from the Department of Environment and Heritage Protection (EHP);
- 1:25,000 topographic map ('Undullah'), produced by the Queensland Department of Mapping and Surveying (SUNMAP);
- Site layouts provided by RPS;
- Rainfall Data from the Greenbank Thompson Road station obtained from the Bureau of Meteorology.
- Cardno's '*Flagstone City – Masterplan Stormwater Management Strategy Report*' dated April 2014 (ref 721743/R10V5);
- Cardno's '*Flagstone City – Masterplan - Flooding Assessment*' dated September 2014 (ref 721743/R1V6).

# 6 Stormwater Management Strategy

## 6.1 Quality

A wide range of stormwater management practices are available to achieve the principles of Water Sensitive Urban Design. All have been shown to be successful when correctly designed, but selection of the most appropriate practices for a particular development is highly dependent on site conditions. The review of these practises is contained in Cardno's '*Flagstone City – Masterplan Stormwater Management Strategy Report*' dated April 2014 (ref 721743/R10V5). Of the available measures considered the following are considered suitable for Flagstone City:

- gross pollutant traps to collect oil and grease from car park and manoeuvring areas;
- buffer strips;
- grass swales (with or without underlying infiltration systems);
- bio-retention systems;
- detention basins / sediment basins; and
- constructed wetlands.

Based on the suitable measures and the site constraint elements of Stage 7, it is proposed to utilise the following treatment measures as shown on Figure 2.



**Plate 6.1 – Typical Bio-Retention System**

**Bio-Retention Systems** – The stormwater will be directed to appropriately located and sized bio-retention basins. These systems will improve the water quality by removing:

- Suspended Solids;
- Nutrients; and
- Metals.

The inlet zones of the bio-retention systems will include a flow velocity dissipater and sediment forebay to provide protection for the bio-retention basins.

## 6.2 Quantity

The management of the water quantity and site flooding is proposed to be address as a Masterplan solution. This strategy will provide an integrated approach to the flooding to provide the most cost effective solution both in terms of construction and on-going maintenance. The details of the flood management are contained in Cardno's '*Flagstone City – Masterplan - Flooding Assessment*' dated September 2014 (ref 721743/R1V6), which specifies the mitigation is achieved by providing restricted openings at all future road crossings. There is no additional excavation of the floodplain.

The assessment contained in this report will detail which mitigation measures designed for the masterplan are recommended to be included for this stage to ensure the flooding performance criterion (Section 4) are met.

# 7 Water Quality Assessment

## 7.1 Approach

The water quality assessments were undertaken utilising MUSIC Version 5.00.11 in accordance with Healthy Waterways '*MUSIC Modelling Guidelines*' (Version 1.0 2010).

The catchment extents adopted for the MUSIC model are presented on Figure 3, with the details of the catchment areas and land uses detailed in Table 7-1 below. A schematic of the MUSIC model layout is provided in Appendix C.

**Table 7-1 Modelled Areas**

| Catchment Label | Land Use Area (ha) | | | | | | | Catchment Total Area (ha) |
|---|---|---|---|---|---|---|---|---|
| | Urban Residential | | | Commercial | | | Open Space | |
| | Roof | Ground | Road | Roof | Ground | Road | | |
| North | 0 | 0 | 0 | 2.458 | 0.983 | 1.475 | 0 | 4.915 |
| South | 0 | 0 | 0 | 2.249 | 0.900 | 1.350 | 0 | 4.499 |

The rainfall data used in the modelling was the Greenbank Thompson Road station 40659 obtained from the Bureau of Meteorology. A ten year period between 1980 and 1989 was assessed. The potential evapotranspiration details were obtained from the Healthy Waterways 2009 modelling guidelines.

The stormwater quality improvement devices assessed in the MUSIC model include bio-retention systems as discussed above and shown on Figure 2:

The following assumptions were made in the modelling:

- A 6 minute time step was adopted to ensure accurate assessment of the proposed treatment devices;
- The pollutant generation parameters are adopted from Healthy Waterways 'MUSIC Modelling Guidelines' (Version 1.0, 2010) and can be found in Appendix C;
- The following fraction impervious values were adopted in the MUSIC model:
  - Roofs = 100%
  - Commercial Ground = 80%
  - Commercial Road (including road reserve) = 75%
- No flow routing was assumed, which provides a conservative estimate of treatment device efficiency;
- Default MUSIC pollutant removal efficiencies were adopted for all treatment devices;

## 7.2 Results

Table 7-2 below presents the outcomes from the MUSIC modelling compared to the required load based reductions.

**Table 7-2 Pollutant Load Reductions**

| Pollutant | Annual Load (kg/yr) | | Load Reduction – Mitigated to Post-Dev (kg/yr) | Percentage Load Reduction – Mitigated to Post-Dev (%) | Required Load Reduction (%) | Meet Load Reduction Requirement ? |
|---|---|---|---|---|---|---|
| | Post-Development | Mitigated | | | | |
| TSS | 9870 | 1670 | 8200 | 83.1 | 80 | Yes |
| TP | 23.1 | 9.15 | 14.0 | 60.4 | 60 | Yes |
| TN | 190 | 84.9 | 105.1 | 55.3 | 45 | Yes |
| GP | 1510 | 0 | 1510 | 100 | 90 | Yes |

The above results indicate that the proposed treatment train is predicted to meet the required water quality load based reductions.

Table 7-3 below provides the bio-retention basin filter areas required to meet the load reduction objectives for Stage 7.

**Table 7-3 Bio-Retention Basin Parameters**

| Parameter | North | South |
|---|---|---|
| Extended Detention Depth (m) | 0.3 | 0.3 |
| Surface Area ($m^2$) | 520 | 480 |
| Filter Area ($m^2$) | 520 | 480 |
| Saturated Hydraulic Conductivity (mm/hr) | 200 | 200 |
| Filter Depth (m) | 0.5 | 0.5 |
| TN Content of Filter Media (mg/kg) | 400 | 400 |
| OP Content of Filter Media (mg/kg) | 50 | 50 |
| Exfiltration Rate (mm/hr) | 0 | 0 |
| Is Based Lined? | No | No |
| Vegetated with Effective Nutrient Removal Plants? | Yes | Yes |
| Underdrain Present? | Yes | Yes |
| Submerged Zone with Carbon Present? | No | No |
| Overflow Weir Width (m) | 2 | 2 |

# 8 Waterway Stability Assessment

## 8.1 Approach

To determine the volumes required to limit the 1 year post-development flows to the 1 year pre-development conditions, a local WBNM assessment of the local catchment as shown on Figure 3 was undertaken. The required storage volumes for the detention basins were determined in WBNM.

The local WBNM model was calibrated to the Rational Method peak flows for the Stage 7 catchments. The site has been divided into catchments, namely "EC1" (northern area) and EC2 (southern area). For the local catchment modelling, a Lag factor of 1.7, initial loss of 15mm and continuing loss of 2.5mm/hr were adopted.

The Rational Method peak flow parameters and calculated peak discharges are summarised in Table 8-1 below.

**Table 8-1 Rational Method and WBNM Peak Discharges for Stage 7 Catchments**

| Catchment | Area (ha) | C1 | Tc (min) | 1 Year Intensity (mm\hr) | 1 Year ARI Peak Discharge (m3/s) | WBNM Peak Discharge (m3/s) |
|---|---|---|---|---|---|---|
| EC1 | 4.91 | 0.472 | 29 | 52.0 | 0.33 | 0.32 |
| EC2 | 4.50 | 0.472 | 29 | 52.0 | 0.31 | 0.30 |

The 1 Year ARI peak discharges for the existing and developed scenarios predicted by the local WBNM model are summarised in Table 8-2. The results in the table demonstrate that the developed case peak discharges would be increased. Therefore, it is proposed to utilise detention basins to mitigate the increased peak discharges back to the existing peak flow rates.

**Table 8-2 1 Year ARI Existing and Developed Case WBNM Peak Discharges**

| Catchment | Peak Discharge ($m^3/s$) | |
|---|---|---|
| | Existing | Unmitigated |
| EC1 | 0.32 | 1.05 |
| EC2 | 0.30 | 0.89 |

## 8.2 Results

The local WBNM model was used to determine the detention requirements of the Stage 7 catchments. The proposed basins were assumed to have a batter slope of 1(V):4(H), with a depth of 1 meter. It can be noted that the bottom 0.3 meters represents the extended detention depth (EDD) for stormwater quality treatment. For the modelling, it was assumed that each of the proposed detention basins has a starting water level of 0.3 meters, thereby ensuring that the EDD is not available for peak discharge mitigation.

The details of the proposed detentions basins are provided in Table 8-3. The results of the detention basin modelling are provided in Table 8-4. The results demonstrate that the proposed detention basins would mitigate the developed peak discharges back to the existing peak flow rates. Therefore, these detention basins would be incorporated in the regional WBNM model.

**Table 8-3 Details of Proposed Detention Basins**

| Catchment | Base Area ($m^2$) | Total Depth including 0.3m extended detention Depth (m) | Low Flow Pipe Diameter (mm) | Weir Crest (m) | Weir width (m) |
|---|---|---|---|---|---|
| EC1 | 1,226 | 1.0 | 450 | 0.9 | 2.0 |
| EC2 | 984 | 1.0 | 450 | 0.9 | 2.0 |

**Table 8-4 Detention Basin Modelling Results**

| Catchment | 1 Year ARI Peak Discharge (m3/s) | | | Ponding Depth Including EDD (m) |
|---|---|---|---|---|
| | Existing | Unmitigated | mitigated | |
| EC1 | 0.32 | 1.05 | 0.32 | 0.95 |
| EC2 | 0.30 | 0.89 | 0.29 | 0.94 |

# 9 Hydrologic Assessment

A hydrologic assessment has been undertaken to quantify both the pre- and post-development runoff characteristics of the local tributaries. The results of the hydrologic model was used for input into the hydraulic model (TUFLOW).

The flood model established and reported in Cardno's '*Flagstone City – Masterplan - Flooding Assessment*' dated September 2014 (ref 721743/R1V6), was utilised for this flood assessment. The masterplan flooding solution includes several mitigation measures to mitigate the impact of the entire Flagstone City development. Hence, it is intended to consider the cumulative impacts as the development progresses. This conservative approach allows us to determine when any of the masterplan flooding mitigation measures would be triggered. Therefore the modelling of Stage 7 has assumed that the previous proposed Stage 1 as detailed in our report '*Flagstone City – Stage 1 Stormwater Management Report*' dated 21 November 2014 (ref 7217/43/R2V5) is included in the post development scenario.

## 9.1 Methodology

The hydrologic modelling scenarios are detailed below:

- **Pre-Development (Case EU02e):** This scenario is the pre-development case as detailed in the masterplan assessment (Cardno, Sept 2014 ref 721743/R1V6).
- **Cumulative Impact (Case DU03M):** This scenario assumes the same catchment and land uses as per the pre-development scenario for external catchments. While the fraction impervious values for Stage 1 and Stage 7 catchments were adjusted to reflect the proposed land uses. The Stage 1 catchment details were as per the Stage 1 Stormwater Management Report (Cardno, 21 Nov 2014 ref 721743/R2V5). While for the Stage 7 catchments a fraction impervious factor of 90% has been adopted.

The hydrologic model was assessed with the output utilised as boundary conditions for the hydraulic modelling.

# 10 Hydraulic Assessment

Hydraulic analysis has been performed to determine peak flood levels through the site and to ensure development on the site will remain flood free and not adversely impact on other properties external to the site in accordance with the Performance Criteria (Section 4).

The flood model established and reported in Cardno's '*Flagstone City – Masterplan - Flooding Assessment*' dated September 2014 (ref 721743/R1V6), was utilised for this flood assessment.

## 10.1 Methodology

The previously developed two dimensional (2D) model of the site and surrounds adopted a grid size of 10m. The model extent is shown on Figure 4. The hydraulic assessment of the site has been undertaken using the TUFLOW (Build 2011-09-AF), a linked one-dimensional/two-dimensional (1D/2D) hydraulic model.

The following scenarios have been considered:

- **Pre-Development Case** (Case E21e): The pre-development topography modelled is shown on Figure 4, as is the Pre-Development case as detailed in the masterplan assessment (Cardno, Sept 2014 ref 721743/R1V6).
- **Post-Development or Cumulative Impact** (Case EC): This cumulative impact scenario is includes the proposed Flagstone Stage 1 and Stage 7 inflows and topographic changes.

## 10.2 Hydraulic Model Results

Maps of post-developed peak flood levels and impacts are shown in Appendix C and D, respectively. Table 10-1 below presents the pre- and post-development predicted peak flood levels and cumulative impacts for key locations within the model extent (refer Appendix B figures for reporting point locations). The Tables in Appendix E show the predicted peak flood levels and impacts for all the relevant reporting nodes for the 2 Year to 100 Year ARI event. In Appendix F pre and post-developed time series flood levels downstream of the site can be found for all events considered in this report.

The hydraulic modelling results demonstrate that the cumulative development of the Stage 7 and the Stage 1 will not cause any significant adverse flooding impacts external to the overall Flagstone City development extent.

**Table 10-1 100 Year ARI Predicted Peak Flood Levels**

| Reporting Node ID | Peak Flood Level (mAHD) | | Impact (m) |
|---|---|---|---|
| | Pre-Developed | Post-Developed | |
| H_SDYCK_DS3_CH9400 | 24.46 | 24.45 | -0.004 |
| H_SDYCK_DS3_CH8900 | 25.91 | 25.91 | -0.003 |
| H_SDYCK_DS2_CH7500 | 29.59 | 29.58 | -0.009 |
| H_SDYCK_CH7000 | 31.26 | 31.25 | -0.007 |
| H_SDYCK_US1_CH6400 | 33.11 | 33.10 | -0.006 |
| H_SDYCK_DS1_CH6250 | 34.12 | 34.11 | -0.011 |
| H_SCBRIDGE_DS_CH5550 | 36.29 | 36.28 | -0.009 |
| H_SDYCK_BRIDGE1_US_CH5200 | 37.67 | 37.66 | -0.013 |
| H_SDYCK_CH4900 | 38.89 | 38.88 | -0.004 |
| H_SDYCK_CH4700 | 39.41 | 39.40 | -0.004 |
| H_SDYCK_CH4200 | 41.19 | 41.19 | -0.003 |
| H_SDYCK_CH3700 | 43.19 | 43.20 | 0.005 |
| H_SDYCK_CH3500 | 44.10 | 44.09 | -0.009 |
| H_SDYCK_CH3000 | 45.84 | 45.84 | -0.007 |
| H_SDYCK_CH2650_Trib1 | 59.70 | 59.70 | 0.000 |
| H_SDYCK_CH2650_Trib2 | 57.40 | 57.40 | 0.000 |
| H_SDYCK_CH2400 | 48.05 | 48.05 | 0.001 |
| H_FSTCK_CH10800 | 21.74 | 21.74 | -0.004 |
| H_FSTCK_CH10200 | 23.20 | 23.19 | -0.003 |
| H_FSTCK_CH9700 | 24.38 | 24.38 | -0.002 |
| H_FSTCK_CH9100 | 26.07 | 26.07 | 0.000 |
| H_FSTCK_CH8500 | 28.52 | 28.52 | 0.000 |
| H_FSTCK_CH7500 | 32.83 | 32.83 | 0.000 |
| H_FSTCK_CH7300_trib1 | 41.88 | 41.88 | 0.000 |
| H_FSTCK_CH7300_trib2 | 40.70 | 40.70 | 0.000 |
| H_FSTCK_CH6900 | 36.33 | 36.33 | 0.000 |
| H_FSTCK_CH6700 | 37.12 | 37.12 | 0.000 |
| H_FSTCK_CH6350 | 39.19 | 39.19 | 0.000 |
| H_FSTCK_CH6250 | 39.83 | 39.83 | 0.000 |
| H_FSTCK_CH5100 | 45.65 | 45.65 | 0.000 |
| H_FSTCK_CH3800_Trib1 | 54.37 | 54.37 | 0.000 |
| H_FSTCK_CH3800_Trib2 | 53.51 | 53.51 | 0.000 |
| H_FSTCK_CH3350 | 54.54 | 54.54 | 0.000 |
| H_FSTCK_CH3200 | 55.67 | 55.67 | 0.000 |
| H_FSTCK_CH2800 | 57.77 | 57.77 | 0.000 |
| H_FSTCK_CH2000 | 61.22 | 61.22 | 0.000 |
| H_FSTCH_CH10650_TEVRD_US | 22.18 | 22.18 | -0.004 |

# 11 Conclusion

Master Planning is being undertaken with respect to the Flagstone City area. Water sensitive urban design principles are to be adopted to minimise the negative impact of development on the natural water cycle and protect the health of aquatic ecosystems.

Following the definition of suitable performance criteria with respect to the management of stormwater, the options available for achieving the performance criteria were evaluated. The results of the evaluation are summarised below.

- **Quantity**

  The management of the water quantity and site flooding is to be address as a Masterplan solution. This strategy presents an integrated approach to the flooding to provide the most cost effective solution both in terms of construction and on-going maintenance.

  The development of Stage 7 has been demonstrated with the adoption of the local 1 year ARI basins that the Stage 7 development will not have any adverse flood impact external to the site.

- **Quality**

  A review of available treatment methods indicated several treatment methods were suitable for use. Based on the sites constraints and opportunities, it was determined that to treat the East Commercial the treatment train is to consist of bio-retention systems.

  It is expected that the list of appropriate treatment methods will alter over time as technology advances. Provided that the objectives can still be achieved, the use of improved management techniques is to be encouraged.

  The objectives relating to the quality management for Stage 7 includes:

  - protection of stream ecology and geomorphology from impacts of stormwater runoff; and
  - adoption of Healthy Waterways '*Concept Design Guidelines for Water Sensitive Urban Design*' (2009) including:
    - Waterway Stability Management; and
    - Stormwater Management.

  The modelling detailed in this report confirmed that the proposed development with the proposed treatment train will achieve all of the above objectives. Thereby confirming that the environmental values of downstream watercourses can be protected.

# 12 References

Cardno, 2014, *'Flagstone City – Stage 1 –Stormwater Management Report'* (ref 721743/R2V5)

Cardno, 2014, *'Flagstone City – Masterplan – Flooding Assessment'* (ref 721743/R1V6)

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Flagstone City - Stage 7

# FIGURES


Figure 1 Site Location and Layout Plan

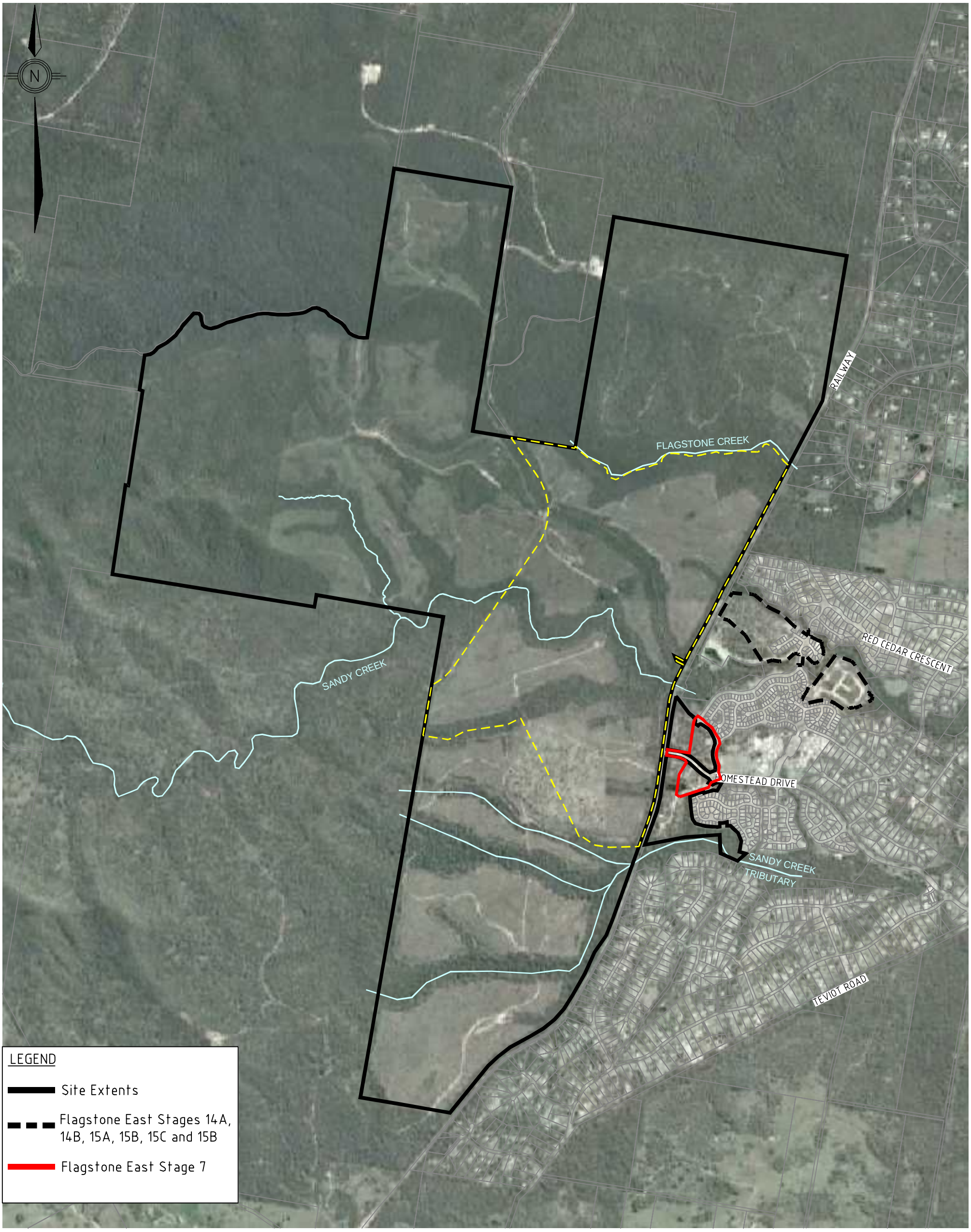
Figure 2 Stormwater Management Strategy

Figure 3 Catchment Plan

Figure 4 Pre-Development Model Topography & Inflow Boundary Locations

Figure 5 Post-Development Model Topography, Inflow Boundary Locations & Mitigation Measures


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250 0 250 500 750 1000 1250m
1:25,000

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Scale 1:25,000 (A3)

FIGURE 1
SITE LOCATION

**Rev: 1 | Drawn: J.M. | Checked: D.N. | Date: 26/08/2014**

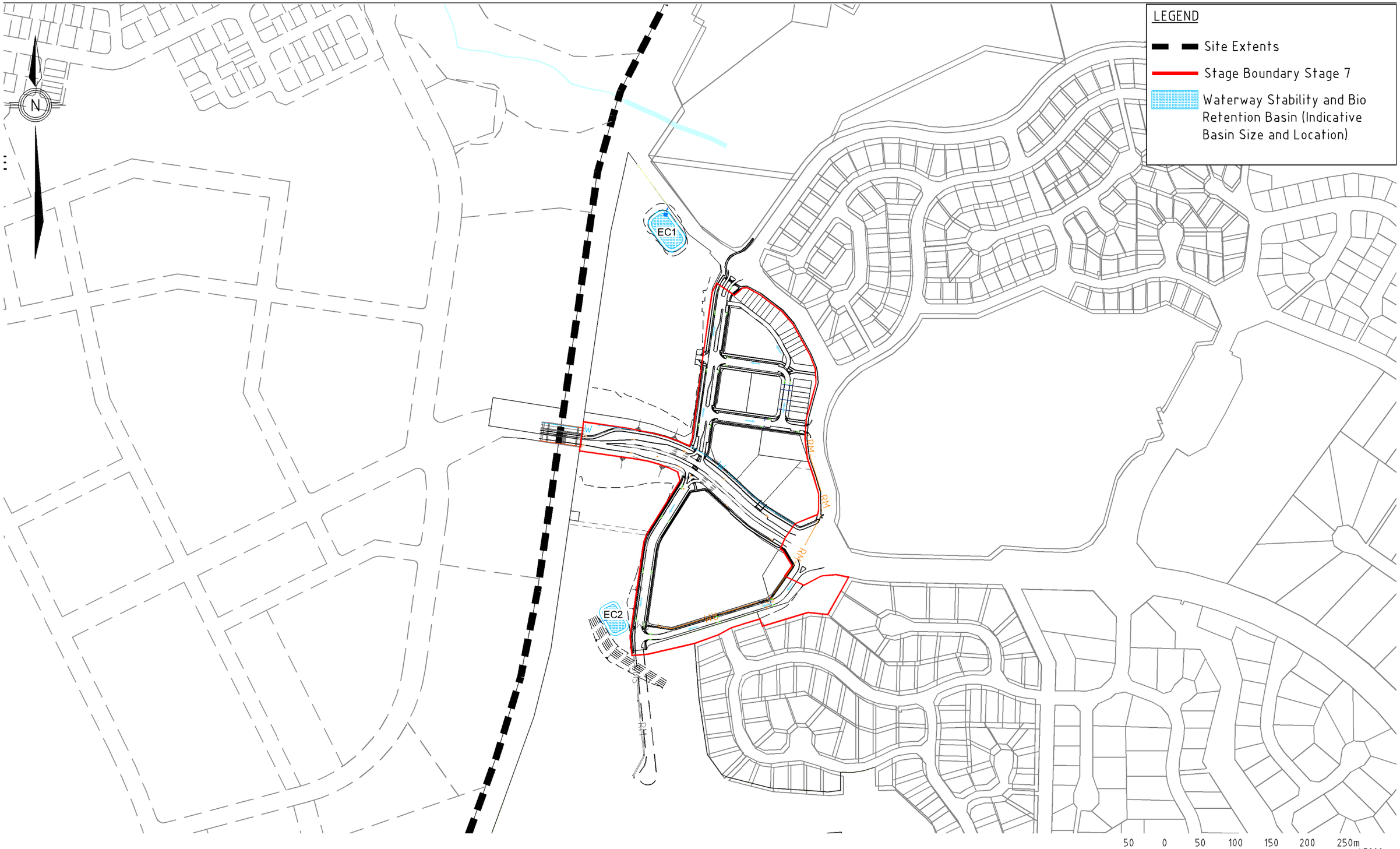
**Project No.: 7217/43**

Flagstone City Pty Ltd

CAD FILE: P:\721743 Flagstone City\11\Cad\02 Figures\Stage 1\SS\141202\Figure 1 - Site Location_v4.dwg
XREF's: X - 721743011_BASE STAGE 1

PRINT DATE: 03 December, 2014 - 2:24pm

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Notes:
- Indicative size and location of basins subject to detailed design

Scale 1:5,000 (A3)

# FIGURE 2
# STORMWATER MANAGEMENT STRATEGY

Rev: 1 | Drawn: J.M. | Checked: D.N. | Date: 25/08/2014

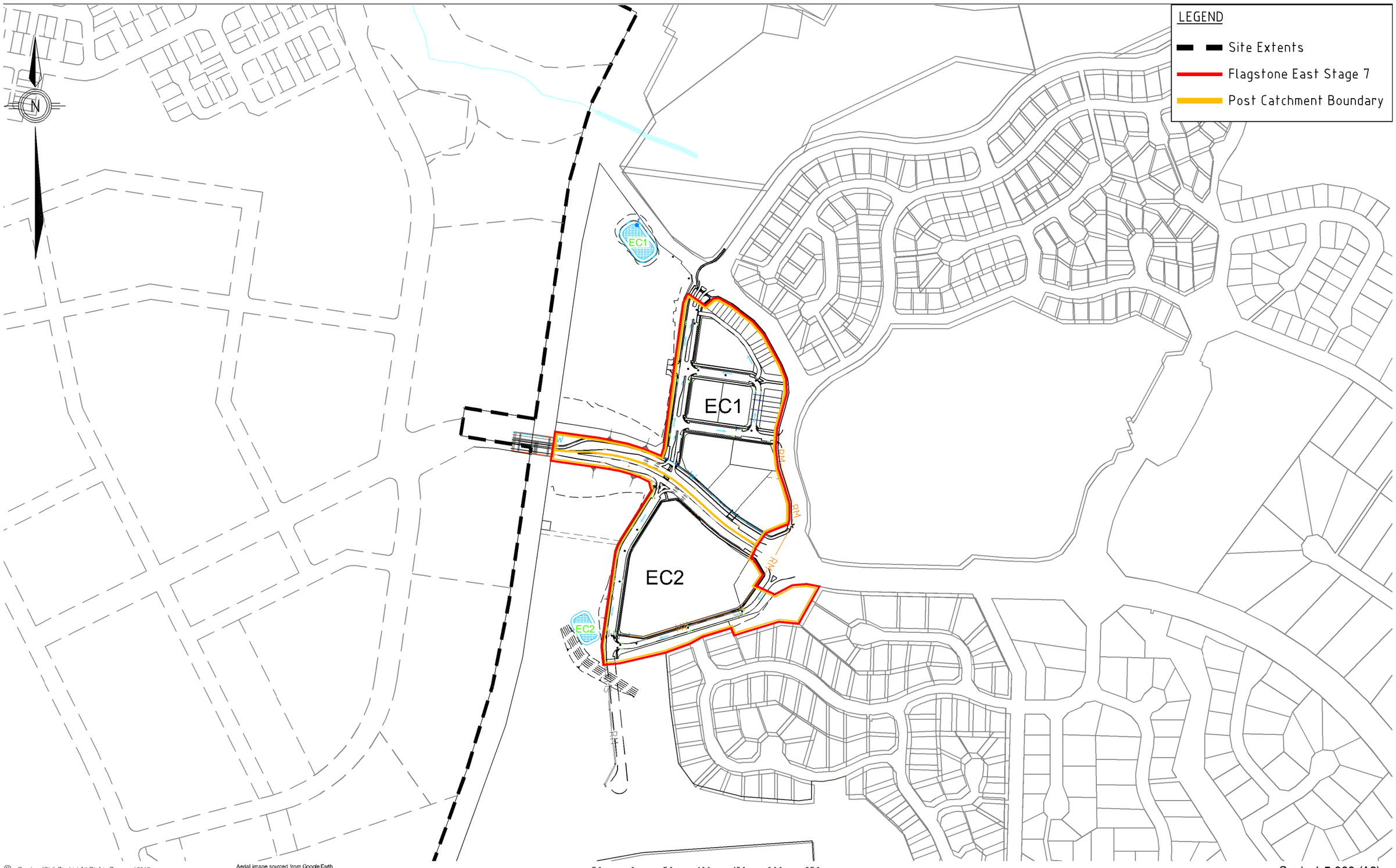
Project No.: 7217/43

Flagstone City Pty Ltd

PRINT DATE: 05 December, 2014 - 10:26am

CAD FILE: P:\7217\43 Flagstone City\33 POD East Commercial\01 - DESIGN PHASE_Drawings_Working\Figure 2 - Stormwater Management Strategy_v3.dwg
XREF's: X - 7217\43011_BASE STAGE 1; X_7217\43033 - Design Bdys; X_7217\43033 - Design Base; X_7217\43033 - Survey

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# FIGURE 3
# CATCHMENT PLAN

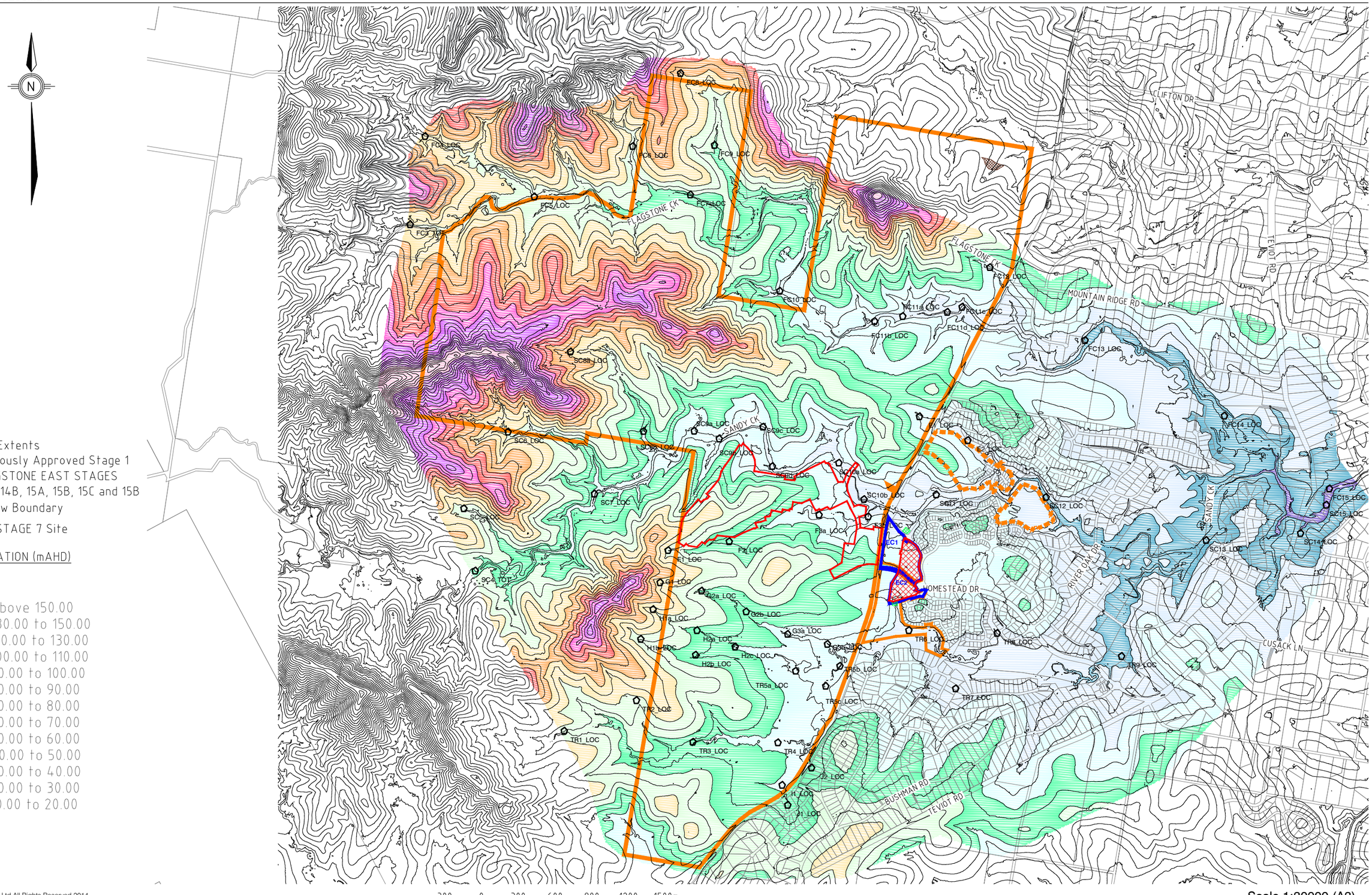
Rev: 1 | Drawn: J.M. | Checked: D.N. | Date: 25/08/2014

Project No.: 7217/43

Flagstone City Pty Ltd

CAD FILE: P:\7217\43 Flagstone City\11\Cad\02 Figures\Stage 1\SS\141202\Figure 3 - Catchment plan_v3.dwg
XREF's: X_7217\43033 - Design Base; X_7217\43033 - Design Bdys

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Scale 1:30000 (A3)

**FIGURE 4**

# TUFLOW Model - Pre-Development Model Topography and Inflow Boundary Locations

Rev: Orig. Date: 01 December 2014

Project No.: 7217/43

Peet Flagstone City Pty Ltd

CAD FILE: D:\7217-43\FlagstoneEast\Commercial\Acad\Figures\Figure 4 and Figure5.dwg
XREF's: Existing Contours; 110056-73 and 110056-85 combined; Inflow points; Topo_EXG_E18_10m; X-Road and Creek labels

PRINT DATE: 03 December, 2014 - 10:24am

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LEGEND

- Site Extents
- Stage 1 Catchment Extent
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Previously Approved Stage 1 Q1 Basin
- STAGE 7 Q1 Basin
- EC1 STAGE 7 Catchment
- FC3_TOT Inflow Boundary

ELEVATION (mAHD)

- Above 150.00
- 130.00 to 150.00
- 110.00 to 130.00
- 100.00 to 110.00
- 90.00 to 100.00
- 80.00 to 90.00
- 70.00 to 80.00
- 60.00 to 70.00
- 50.00 to 60.00
- 40.00 to 50.00
- 30.00 to 40.00
- 20.00 to 30.00
- 10.00 to 20.00

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300 0 300 600 900 1200 1500m
1:30,000

Scale 1:30000 (A3)

**FIGURE 5**

# TUFLOW Model - Post-Development Model Topography and Inflow Boundary Locations and Mitigation Measures

Rev: Orig. Date: 01 December 2014

Project No.: 7217/43

Peet Flagstone City Pty Ltd

CAD FILE: O:\7217-43\FlagstoneEastCommercial\Acad\Figures\Figure 4 and Figure5.dwg
XREF's: Existing Contours; 110056-73 and 110056-85 combined; Inflow points; Topo_EXG_E18_10m; X-Road and Creek labels

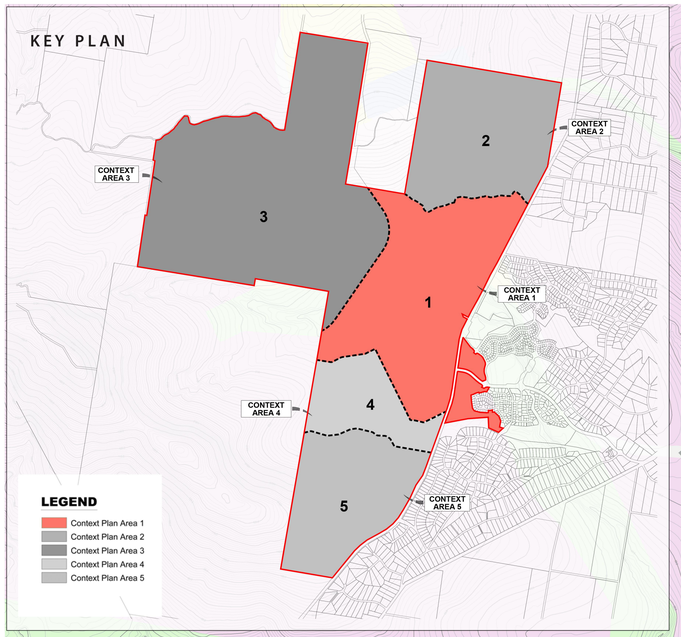
PRINT DATE: 03 December, 2014 - 12:28pm

Flagstone City - Stage 7

# REFERENCE DRAWINGS

Cardno
Shaping the Future

KEY PLAN




FUTURE RESIDENTIAL DEVELOPMENT

CONTEXT PLAN AREA TWO (INDICATIVE FUTURE DEVELOPMENT)

MOUNTAIN RIDGE ROAD

FLAGSTONE CREEK

STAGE FIVE

STAGE FOUR

CONTEXT PLAN AREA THREE (INDICATIVE FUTURE DEVELOPMENT)

STAGE THREE

NORTH SOUTH ARTERIAL

CONTEXT PLAN AREA ONE

STAGE TWO

SANDY CREEK

STAGE ONE

BALANCE STAGE

STAGE ONE

STAGE SIX

Flagstone State Community College

STAGE SEVEN

HOMESTEAD DRIVE

STAGE SIX

FUTURE RESIDENTIAL DEVELOPMENT

CONTEXT PLAN AREA FOUR (INDICATIVE FUTURE DEVELOPMENT)

Coachwood Park

CONTEXT PLAN AREA FIVE (INDICATIVE FUTURE DEVELOPMENT)

LEGEND

- Flagstone West Site Boundary
- Context Area One Site Boundary
- Internal Staging Boundaries / Application Boundaries
- Area not within PDA (not in application)
- Rail Line
- Proposed Rail Station
- Railway Corridor Expansion
  Potential Land Dedication – Salisbury to Beaudesert Rail Corridor
  Note: Refer condition 15 DEV2012/209
- 400m & 800m Walkable Catchments
- Major Road Linkages
- Minor Road Linkages
- Indicative Future Road Linkages
- Remnant Vegetation - Core Conservation
- Linear Open Space Network / Stormwater Management
- District Recreation Park
- Regional Recreation Park
- Neighbourhood Recreation Node
- Civic Park Node
- School and /or Child Care
- Community Facility
- Low Density Residential - 15 dw / ha
- Town Centre Core (Residential - Minimum 60dw / ha)
- Town Centre Frame (Residential - Minimum 40dw / ha)
- Potential Service Station

**FLAGSTONE Context Area One**
**Context Plan**

0 100 200 400

**Disclaimer**

The contents of this plan are conceptual and for discussion purposes only. All areas and dimensions are approximate and subject to relevant studies, survey, engineering and Council approval.

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**Scale** 1:4000@A0 | **Date** September 2014 | **Project No.** 110056_112H

Flagstone City - Stage 7

# APPENDIX A

## Stormwater Management Plan

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# Stormwater Management Plan

## Water Quality Management – Construction Phase

| Issue: | Water Quality Management – Construction Phase |
|---|---|
| Operational Policy: | To provide a set of guidelines to control the severity and extent of erosion and pollutant transport during firstly the earthworks stage, and then construction. |
| Performance Criteria: | Water discharges off the site are to comply with the Environmental Protection Act to ensure that no detrimental impacts on water quality and aquatic environment occur during the construction phase.<br>The quality of discharge from the site should not exceed the Water Quality Objectives, as follows:<br>Release Criteria<br>pH – 6.5 - 9.0 (range)<br>Suspended Solids < 50mg/L ($90^{th}$ percentile).<br>DO > 80 % saturation or 6 mg/L ($90^{th}$ percentile).<br>Litter – no visible litter washed from site.<br>Hydrocarbons - No visible sheen on receiving waters |
| Responsibility: | The owner of the property or their appointed representative & the Construction Contractor. The owner will be responsible for the implementation of the control measures and monitoring during the course of all construction activity. |
| Implementation Strategy: | A detailed erosion and sediment control plan is to be prepared by the project's civil engineers and will incorporate the following:<br>• Sediment and erosion control is to be in accordance with the Institution of Engineers Australia *'Soil Erosion and Sediment Control -Engineering Guidelines for Queensland Construction Site (June 1996)'*, The International Erosion Control Associastion *'Best Practice Erosion and Sediment Control (2008)'* and current local best practice engineering and environmental management. |
| | Earthworks will be completed in stages with works restricted to the immediate areas. |
| | Subsequent stages of development should not commence if prior stages are affected by acid sulphate conditions &/or construction phase water quality objectives are not met. |
| | Prior to the commencement of any stage construction works temporary sediment basins are to be installed as per the details shown in the stages construction phase stormwater management strategy. |
| | All disturbed site discharge to pass through temporary sediment basins prior to discharge from the site. |
| Implementation Strategy (Cont'd): | Catch drains should be installed to divert upstream 'clean' water.<br>Silt fences will be placed along the downstream extents of all earthworks.<br>Check dams will be installed at regular intervals along catch drains. |
| | Drains and bund walls will be topsoiled and vegetated with suitable vegetation as soon as possible. |
| | Sediment and sludge trapped in the basins will be removed and mixed with topsoil and reused on site for landscaping purposes. |
| | Clean-up of general site litter on a weekly basis and after significant rainfall events. (>25mm/24hours) |
| | Landscaping activities and revegetation will occur as soon as possible during/after the construction phase of the development.<br>Only appropriate herbicides and fertilisers are to be used. |

| Issue: | Water Quality Management – Construction Phase |
|---|---|
| Monitoring: | Sediment and erosion control measures will be inspected daily by the site manager during periods of rainfall. (>25mm/24hrs)<br>Establishment and growth of vegetation – to be monitored monthly.<br>No occurrence of excessive sediment deposit - to be monitored weekly or daily during periods of heavy rainfall (>25mm/24hrs).<br>No release of construction material and silt from the site – to be monitored weekly or daily during periods of heavy rainfall (>25mm/24hrs).<br>Vegetation established and growing prior to the rainy season.<br>Erosion monitoring immediately following heavy rainfall. (>25mm)<br>Inspection of silt fences and check dams following heavy rainfall. (>25mm/24hrs)<br>Water quality monitoring shall be carried out following a rainfall event (>25mm of rainfall), and prior to discharge water quality monitoring will be conducted on the waters detained in the sediment basins and at the discharge point for the site.<br>The parameters to be tested shall include:<br>• Surface waters: Rainfall Event<br>• Parameters: Temperature, dissolved oxygen, pH, specific conductance, salinity, turbidity, suspended solids and litter.<br>• Water collected in basins: Prior to release<br>• Parameters: pH, suspended solids.<br>Note that additional water quality monitoring may be required if the WQOs are not being met. |
| Auditing: | Reviews are to be carried out on a monthly basis to assess the implementation strategy. A checklist is to be completed which assesses the strategies listed above. |
| Identification of Incident or Failure: | Non compliance with agreed performance criteria will be identified by:<br>• Visual inspections identifying:<br>• build up of sediment on and off the site.<br>• Excessive erosion on the site<br>• Release of construction material from the site<br>• Lack of vegetation establishment<br>• Poorly maintained, damaged or failed control devices.<br>• Deteriorated water quality identified by the Environmental Consultant as being attributable to the construction activities. |
| Corrective Action: | After any identification of incident or failure, the source is to be located immediately and the following measures implemented:<br>• If vegetation growth fails, new vegetation should be planted and established. Vegetation may require supplementary watering & replanting.<br>• If silt fences fail, replace and monitor more frequently.<br>• If gully erosion occurs, fill, vegetate and install velocity dissipation steps.<br>If release of silt and other material off the site occurs, or water quality monitoring indicates levels not within the WQOs, clean up, inspect all treatment techniques, revise designs and review different alternatives and install, otherwise reduce the rate of excavation.<br>If monitored levels within the sediment basins do not conform to the release criteria for:<br>• Suspended solids: flocculate and retest.<br>• pH: add acid if pH is too high or add hydrated lime if pH is too low and retest. |

| Issue: | Water Quality Management – Construction Phase |
|---|---|
| Reporting: | Reports will be submitted monthly during the construction of each stage. The reporting will include:<br>• Construction Contractor site managers report; and<br>• Environmental Consultant water quality monitoring report<br>Reporting will identify performance of the implementation strategy, monitoring, identification of incidents/failure and associated corrective action. Reports will be submitted to the owner (or their appointed representative) monthly for submission to Council. |

# Water Quality Management Operational Phase

| Issue: | Water Quality Management – Operational Phase |
|---|---|
| Operational Policy: | To provide a concise plan to ensure that the water quality in the waterways remain at an acceptable level as specified in the water quality objectives (WQOs) for the site at all times and to ensure that any waters discharged from the site are of an acceptable quality. |
| Performance Criteria: | Water discharges off the site should be of a quality, which ensures there is no detriment to the downstream environment.<br>Performance criteria for the site are:<br>– 80% reduction in sediment load;<br>– 60% reduction in total phosphorus load;<br>– 45% reduction in total nitrogen load; and<br>– 90% reduction in gross pollutant load. |
| Responsibility: | The owner of the property or their appointed representative. The owner will be responsible for a period of 12 months after completion of construction. |
| Implementation Strategy: | A comprehensive conceptual stormwater runoff management system is proposed for the development, comprising local runoff water quality control.<br>Local catchment runoff water quality control is achieved by bio-retention systems. |
| | These controls will:<br>• trap coarse sediment and attached nutrients and heavy metals; and<br>• remove nutrients; |
| | Periodical monitoring of erosion or sediment deposition within treatment devices. |
| Implementation Strategy (cont'd): | Periodic maintenance of vegetation within the treatment devices.<br>Inspection of basin for clogging. |
| Monitoring: | Inspect outflow points from the stormwater outlets and treatment trains to ensure that there are no signs of erosive activity or significant sediment deposits.<br>Monitoring shall include inspection of all treatment devices to ensure they are operating efficiently. |
| Auditing: | Reviews are to be carried out on a monthly basis to assess the implementation strategy. A checklist is to be completed which assesses the strategy against each of the monitoring points above. |
| Identification of Incident or Failure: | Non compliance with agreed performance criteria will be identified by:<br>• Visual inspections identifying:<br>• build up of sediment and litter on and off the site.<br>• Excessive erosion on the site<br>• Release of construction material from the site<br>• Lack of vegetation establishment<br>• Poorly maintained, damaged or failed control devices.<br>• Deteriorated water quality identified by the Environmental Consultant as being attributable to the site operations. |

| Issue: | Water Quality Management – Operational Phase |
|---|---|
| Corrective Action: | Harvesting of vegetation within the bio-retention systems and re-establishment if vegetation is not healthy.<br>If vegetation fails, new vegetation should be planted and established. Vegetation may require supplementary watering and replanting. |
| | If erosion occurs, fill, vegetated and/or install velocity dissipation. To be in accordance with the Institution of Engineers Australia *'Soil Erosion and Sediment Control -Engineering Guidelines for Queensland Construction Site (June 1996)*' and the International Erosion Control Associastion *'Best Practice Erosion and Sediment Control (2008)*'. |
| | If release of silt and other material off the site occurs, clean up, inspect all treatment techniques, revise designs and review different alternatives and install. |
| | If poor water quality continues to occur, inspect all treatment techniques, revise designs and review different alternatives and install. |
| Reporting: | An Inspection Report for all water quality monitoring shall be submitted to Council, following a monitoring campaign for up to 2 years after the construction phase. |

Flagstone City - Stage 7

# APPENDIX B

## Maintenance Plans

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# 1 Introduction

Bio-retention systems are vegetated areas where runoff is filtered through a porous sandy loam filter media as it infiltrates through the system to an arrangement on perforated under-drains and flows to downstream waterways.

Runoff is allowed to temporarily pond to increase the volume of stormwater runoff treated through the bio-retention systems. The temporary ponding level is generally referred to as the extended detention depth.

To protect against possible scour of the bio-retention surface, high flows that exceed the design event are conveyed through an overflow pit or high-flow bypass channel.

# 2 Function

Bio-retention basins operate by filtering stormwater runoff through densely planted surface vegetation and percolating through a specified filter media. Pollutants within the stormwater runoff are retained through fine infiltration, adsorption and some biological uptake as the runoff percolates through the filter media. The vegetation in a bio-retention system is a vital functional element to the operational effectiveness of the bio-retention system, providing a substrate for biofilm growth within the upper layer of the bio-retention filter media and facilitates the transport of oxygen to the filter media enhancing soil microbiological communities and the biological transformation of pollutants.

Bio-retention basins are not intended to be an infiltration system that discharges the treated stormwater runoff into the surrounding in-situ soils. Bio-retention systems are generally designed to recover stormwater at the base of the filter media in the perforated under-drain and discharge to receiving waters. In order to accommodate this feature an impermeable geotextile fabric is placed between the in-situ soils of the bio-retention walls and base to limit exfiltration to the surrounding soils.

Bio-retention systems can be installed at various scales, including:

- Landscape planter boxes;
- Roadside rain gardens incorporating traffic calming measures;
- Within suburban Parks; and
- At the base of detention basins.

Generally in larger applications a pre-treatment swale or vegetated buffer area is incorporated upstream of the bio-retention system to minimise the maintenance frequency of the bio-retention system.

# 3 Construction and Establishment

Following the completion of the civil construction phase (i.e. bulk earthworks, roads and services) the site is opened for the build out of each of the individual lots. At this time the works are generally 'uncontrolled' as individual builders not associated with the developer will undertake the individual lot construction. Based on practical experience this stage is usually detrimental to the water quality management and establishment of the water quality treatment devices. The following details a recommended construction and establishment methodology for a bio-retention basin.

## 3.1 Functional Installation

The Functional Installation of a bio-retention basin occurs at the end of the bulk civil works (i.e bulk earthworks, installation of roads, water, sewage and power services) as part of the landscaping works. The functional installation involves:

- Bulking out and trimming (Basin excavation);
- Installation of the bio-retention basin outlet structures;
- Placement of a geo-textile fabric (between the in-situ basin bed and the drainage layer)
- Installation of the drainage layer and under-drain system;
- Placement of the transition layer and filter media;
- Installation of bio-retention inlet structures;
- Placement of a temporary protective management strategy (Refer to sediment and erosion details below).
- Placement of sediment fences around the boundary of the bio-retention basin to prevent silt entering the filter media and restrict access to the basin.
- The temporary protective management strategies are kept in place throughout the entire construction phase.

## 3.2 Sediment and Erosion Control

Sediment and Erosion Control involves the placement of temporary protective management strategies for the period where the upstream catchments are not in their final state and are contributing sediment / litter laden waters which may cause the filter media to clog.

## 3.3 Operational Establishment

Operational Establishment of the bio-retention basin occurs at the completion of the building phase of the development. Operational establishment includes the following works:

- Removal of all accumulated sediment from the sediment fore bay and the basin surface;
- Removal of the temporary turf, topsoil and geotextile fabric;
- Re-profile the bio-retention filter media surface;
- Vegetation of the bio-retention basin in accordance with the landscape design; and
- Regular watering of the vegetation and removal of weeds during the plant establishment phase (generally first two years).

# 4 Vegetation Establishment

Source: WSUD TDG SEQ 2006 Section 5.5.4

## 4.1 Weed Control

Conventional surface mulching of bio-retention basins with organic material like tanbark should not be undertaken. Most organic mulch floats and runoff typically causes this material to be washed away with risk of blocking outlet structures. Adopting high plant densities and where necessary applying a suitable biodegradable erosion control matting to the basin batters will help reduce the risk of weed invasion and limit labour intensive maintenance requirements for weed removal. A heavy application of seedless hydro-mulch can also provide short term erosion and weed control prior to planting with nursery stock. No matting or hydro-mulch should be applied to the surface of the bio-retention basin following the construction phase as this will hinder the filtration capacity of stormwater through the filter media.

## 4.2 Watering

Regular watering of the bio-retention basin vegetation is essential for successful establishment and healthy growth. The frequency of watering to achieve successful plant establishment is dependant upon rainfall, the maturity of the planting stock and the water holding capacity of the soil. The following watering program is generally adequate but should be adjusted (increased) to suit the site conditions:

- Weeks 1-2: 3 Watering campaigns per week;
- Weeks 3-6: 2 Watering campaigns per week; and
- Weeks 7-12: 1 Watering campaigns per week.

After this initial three month watering campaign, watering may still be required, particularly during the first winter (dry period). Watering requirements to sustain healthy vegetation should be determined during ongoing maintenance site visits.

# 5 Maintenance Requirements

Source: WSUD TDG SEQ 2006 Section 5.6

Vegetation plays a key role in maintaining the porosity of the filter media of a bio-retention basin and strong healthy growth of vegetation is critical to its performance. Therefore the most intensive period of maintenance is during the plant establishment period (first two years) when weed removal and replanting may be required.

Inflow systems and overflow pits require careful monitoring, as these can be prone to scour and litter build up. Debris can block inlets or outlets and can be unsightly, particularly in high visible areas. Inspection and removal of debris should be done regularly, and debris should be removed whenever it is observed on a site. Where sediment forebays are adopted, regular inspection of the forebay is required (3 monthly) with removal of accumulated sediment undertaken as required.

For larger bio-retention basins, it is essential that a maintenance access point is designed or and maintained in the bio-retention basin. The size and complexity of the system will guide its design and may involve provision of a reinforced concrete ramp/ pad for truck or machinery access.

Typical maintenance of bio-retention basin elements will involve:

- Routine inspection of the bio-retention basin profile to identify any areas of obvious increased sediment deposition, scouring from storms, rill erosion of the batters from lateral flows, damage to the profile from vehicles and clogging of the bio-retention basin (generally accompanied by a 'boggy' filter media surface);
- Routine inspection of inflow systems, overflow pits and under-drains to identify and clean any areas of scour, litter build up and blockages;
- Removal of sediment where it is smothering the bio-retention basin vegetation;
- Where a sediment fore bay is adopted, removal of accumulated sediment;
- Repairing any damage to the profile resulting from scour, rill erosion or vehicle damage by replacement of appropriate fill (to match on site soils) and revegetating;
- Tilling of the bio-retention basin surface or removal of the surface layer if there is evidence of clogging;
- Regular watering and irrigation of the basin vegetation until plants are established and actively growing;
- Removal and management of invasive weeds (herbicides should not be used);
- Removal of plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule;
- Pruning to remove dead or diseased vegetation material and stimulate growth;
- Monitoring and controlling vegetation pests;
- Inspections should be also conducted following any large storm event to check for scour and other damage;
- All maintenance should be carried out only after a reasonably rain free period when the soil in the bio-retention systems is dry; and
- All maintenance works are to be documented using the attached maintenance inspection form.

If a bio-retention system fails to drain adequately after tilling of the basin surface and other remedial maintenance, the bio-retention system may require resetting. Resetting involves the complete reconstruction of the bio-retention system.

## 5.1 Bio-Retention Typical Maintenance Schedule

| SCHEDULE OF SITE VISITS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Purpose of Visit** | **Frequency** | **J** | **F** | **M** | **A** | **M** | **J** | **J** | **A** | **S** | **O** | **N** | **D** |
| Routine inspection | 12/year | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Annual inspection | 1/year | | | | ✓ | | | | | | | | |
| Routine maintenance | 2/year | | | | ✓ | | | | | | ✓ | | |
| Routine clean out of sediment | 1 / 2 years | | | | ✓ | | | | | | | | |

There are three phases to this maintenance plan which are:

- The establishment phase;
- The inspection and monitoring phase; and
- Cleanout and replacement phase

The above schedule is a guideline only. Routine clean out and maintenance should be scheduled based on the outcome of routine inspection.

| ESTABLISHMENT | |
|---|---|
| 1.1 | The aim of the establishment phase is to ensure appropriate plant establishment within the bio-retention system through adequate weed control and watering. |
| 1.2 | Weed control during the establishment phase focuses on weed growth prevention rather than removal. By adopting high planting densities and if necessary, applying a suitable biodegradable erosion control matting to the basin batters. |
| 1.3 | Regular watering of the bio-retention basin vegetation is essential for successful establishment of the selected plants. Each site will need specific watering requirements but as a guide during the first two weeks there will need to be three visits each week, after this (weeks 3-6) there will need to be two visits each week. The third and final period of establishment maintenance (weeks 7-12) there is only one visit each week required. The Bio-retention Basin Maintenance Checklist provides the schedule of visits and a tick box to help monitor what stage of the establishment phase they are in and provides a record as to whether proper establishment has occurred. |
| **INSPECTION** | |
| **1.** | **Routine Inspection** |
| 1.1 | Routine inspection should be carried out on a regular monthly basis. The purpose of the inspection is to indicate when maintenance of the Bio-retention system is required. |
| 1.2 | Inspections should consider items listed on the Bio-retention Basin Maintenance Checklist |
| **2.** | **Event Inspection** |
| 2.1 | Following bushfires the bio-retention system shall be inspected for damage to the structure, vegetation and filter media. |
| 2.2 | After any significant rainfall events the bio-retention system shall be inspected for damage to the structure, vegetation and filter media. |
| **ROUTINE MAINTENANCE** | |
| **1.** | **Purpose** |
| 1.1 | Maintenance of the bio retention system involves routine inspections of the bio-retention basin profile to identify any areas of obvious increased sediment deposition or scouring. Based on inspections there should be actions taken to remove dead or diseased vegetation, any litter or foreign objects. Filter Media replacement should occur when necessary and any items from checklist that are noted are to be reported to the site manager. |

| | |
|---|---|
| **2.** | **Weed Management** |
| 2.1 | If weeds have been observed during routine inspection, these weeds should be removed from the bio retention system. Weeding generally involves manual removal of perennial species. |
| 2.2 | The aim is to remove the weed including the roots when the weeds are less than 3 months old, otherwise weeds infestation rapidly occurs and is difficult to control. |
| 2.3 | Herbicides should not be used as they would contaminate the water in the creek. |
| 2.4 | The weeds should be disposed offsite at appropriate waste management facility. |
| 2.5 | Replant appropriate plant species, where necessary, in areas that have been extensively weeded. |
| **3.** | **Litter Management** |
| 3.1 | Remove and dispose of litter that may be visible around the bio retention system. |
| **4.** | **Dead or Diseased Vegetation** |
| 4.1 | Remove or dispose of any dead or diseased vegetation within system. |
| **5.** | **Filter Media Replacement** |
| 5.1 | Filter Media replacement is recommended when erosion is evident or system looks unattractive or is not draining in 30 days. Conventional surface mulching with organic material like tank bark, should not be undertaken as most mulch floats and is washed away. |
| **6.** | **Structural Integrity** |
| 6.1 | Report any damage to the structure immediately to the civil engineer |
| 6.2 | Report significant scour to the civil engineer |
| 6.3 | Ensure that the system is draining correctly via visual inspection of a rainfall event. If poor drainage is observed then inspect the outlet pipe for blockage. If the drainage is still poor then contact the civil engineer and arrange for a permeability test to ensure replacement of filter material is not clogged. |
| **EVENT MAINTENANCE** | |
| **1.** | **Purpose** |
| 1.1 | Event Maintenance of the bio retention system involves undertaking any maintenance to the bio-retention system following an event. Based on the event inspections there should be actions taken to remove dead or diseased vegetation, any litter or foreign objects. Filter Media replacement should occur when necessary and any items from checklist that are noted are to be reported to the site manager. Maintenance is in accordance with the Routine Maintenance guidelines listed above. |
| **CLEANOUT AND REPLACEMENT OF SEDIMENT** | |
| **1.** | **Setup and Prepare Site for Cleanout** |
| 1.1 | Notify adjacent residents of cleanout at least three days prior to date of cleanout. |
| 1.2 | Setup equipment onsite. |
| **2.** | **Cleanout of Sediment** |
| 2.1 | The preferred method of cleanout of the bio-retention system is replacing the clogged medium. |
| 2.2 | Position the equipment on the side of the system to allow easy access into the bio retention system and transfer of material into adjacent tipper truck. The truck should be positioned so that water from the truck body drains into the bio retention system. |
| 2.3 | Drain waste in the truck thoroughly before proceeding to the disposal point. |

Flagstone City - Stage 1

APPENDIX

# B1.1

## Bio-retention Construction Inspection Checklist

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## BIO-RETENTION BASIN CONSTRUCTION INSPECTION CHECKLIST

| | | | |
|---|---|---|---|
| Asset ID: | | Inspected By: | |
| | | Date: | |
| Site: | | Time: | |
| | | Weather: | |
| Constructed By: | | Site Manager: | |

| Items Inspected | Checked | | Satisfactory | | Items Inspected | Checked | | Satisfactory | |
|---|---|---|---|---|---|---|---|---|---|
| | Y | N | Y | N | | Y | N | Y | N |
| CONSTRUCTION AND ESTABLISHMENT PHASE | | | | | | | | | |
| A). FUNCTIONAL INSTALLATION | | | | | Structural Components | | | | |
| Preliminary Works | | | | | 15). Location and configuration of inflow systems as detailed in plans | | | | |
| 1). Erosion and sediment control plan adopted | | | | | 16). Location and levels of overflow pits as detailed in plans | | | | |
| 2). Temporary traffic / safety control measures | | | | | 17). Under-drain connected to overflow pits as detailed in plans | | | | |
| 3). Location as detailed in plans | | | | | 18). Concrete and reinforcement as detailed in plans | | | | |
| 4). Basin protected from site runoff | | | | | 19). Set down to correct level for flush kerbs (rain gardens only) | | | | |
| Earthworks and Filter Media | | | | | 20). Kerb opening width as detailed in plans (rain garden only) | | | | |
| 5). Basin bed surface correct shape and slope as detailed in plans | | | | | | | | | |
| 6). Side slope batters as detailed in plans | | | | | B). SEDIMENT AND EROSION CONTROL | | | | |
| 7). Bio-retention dimensions and area as detailed in plans | | | | | 21). Stabilisation immediately following earthworks and planting of terrestrial landscape around basin | | | | |
| 8). Confirm surrounding soils type with design | | | | | 22). Silt fences and traffic controls in place | | | | |
| 9). Confirm filter media specifications in accordance with latest FAWB Guidelines | | | | | 23). Temporary protective turf and topsoil in place | | | | |
| 10). Geotextile fabric placed between in-situ soils and filter media (base and walls) | | | | | | | | | |
| 11). Under-drain installed as detailed in plans | | | | | C). OPERATIONAL ESTABLISHMENT | | | | |
| 12). Drainage layer media as specified | | | | | 24). Sediment removed from fore bay area | | | | |
| 13). Transition layer media as specified | | | | | 25). Temporary protective turf, topsoil and geotextile fabric removed | | | | |
| 14). Extended detention depth as detailed in plans | | | | | Vegetation | | | | |
| | | | | | 26). Planting as designed (species and density) | | | | |
| | | | | | 27). Weed removal and watering as required | | | | |

| FINAL INSPECTION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1). Confirm levels of the inlets and outlets | | | | | 6). Check for uneven settling of banks | | | | |
| 2). Confirm structural element sizes | | | | | 7). Confirm under-drain operational and working | | | | |
| 3). Check side batter slopes | | | | | 8). Confirm inflow systems operational and working | | | | |
| 4). Check vegetation as designed | | | | | 9). Confirm maintenance access is provided | | | | |
| 5). Check bio-retention filter media surface flat and free of clogging | | | | | | | | | |

| COMMENTS ON INSPECTION |
|---|
| |
| **ACTIONS REQUIRED** |
| |
| Inspection Officer's Signature: |

Flagstone City - Stage 1

APPENDIX

# B1.2

## Bio-retention Maintenance Checklist

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## BIO-RETENTION BASIN MAINTENANCE CHECKLIST

| | | | |
|---|---|---|---|
| Asset ID: | | Inspected By: | |
| | | Date: | |
| Site: | | Time: | |
| | | Weather: | |
| Constructed By: | | Site Manager: | |

| Items Inspected | Checked | | Satisfactory | | Action Required |
|---|---|---|---|---|---|
| | Y | N | Y | N | |
| Sediment accumulation an inflow locations? | | | | | |
| Litter within the basin? | | | | | |
| Erosion at inlet or other key structures? | | | | | |
| Traffic / Vehicle damage present? | | | | | |
| Evidence of illegal dumping (e.g. building waste)? | | | | | |
| Vegetation condition satisfactory (density, weeds etc.) | | | | | |
| Watering of vegetation required? | | | | | |
| Replanting require? | | | | | |
| Mowing / Slashing required? | | | | | |
| Clogging of drainage points (sediment or debris)? | | | | | |
| Evidence of ponding? | | | | | |
| Damage / Vandalism to structures present? | | | | | |
| Surface clogging visible? | | | | | |
| Drainage system inspected? | | | | | |
| Resetting of system require? | | | | | |

| COMMENTS ON INSPECTION |
|---|
| |

| ACTIONS REQUIRED |
|---|
| |

| Inspection Officer's Signature: | |
|---|---|

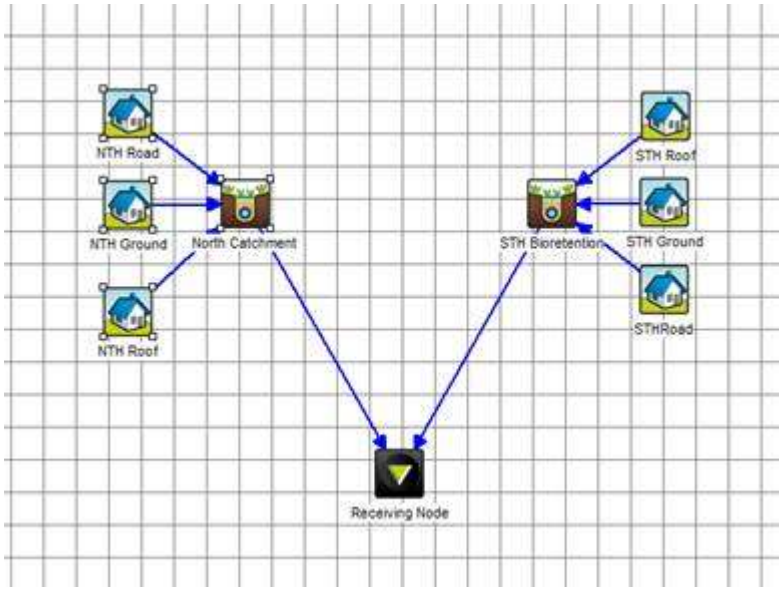
Flagstone City - Stage 7

# APPENDIX C

## MUSIC Model Schematic & Parameters

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## MUSIC Schematic



## MUSIC Parameters (excerpts from Healthy Waterways 'MUSIC Modelling Guidelines' (Version 1.0 2010))

**Table 3.5 Typical impervious fraction for split catchment land use (read with Table 3.3)[7]**

| DEVELOPMENT TYPE | SURFACE TYPE IMPERVIOUS FRACTION (%) | | |
|---|---|---|---|
| | ROAD RESERVE | ROOF | GROUND LEVEL |
| Residential 10 dwellings/ha | 60 | 100 | 15 |
| Residential 15 dwellings/ha | 60 | 100 | 20 |
| Residential 40 dwellings/ha | 70 | 100 | 30 |
| Residential 80+ dwellings/ha | 80 | 100 | 50 |
| Industrial | 75 | 100 | 60 |
| Commercial | 75 | 100 | 80 |

**Table 3.7 Recommended MUSIC rainfall-runoff parameters[9]**

| PARAMETER | LAND USE | | | |
|---|---|---|---|---|
| | URBAN RESIDENTIAL | COMMERCIAL AND INDUSTRIAL | RURAL RESIDENTIAL | FORESTED |
| Rainfall threshold (mm) | 1 | 1 | 1 | 1 |
| Soil storage capacity (mm) | 500[10] | 18 | 98 | 120 |
| Initial storage (% capacity) | 10 | 10 | 10 | 10 |
| Field capacity (mm) | 200 | 80 | 80 | 80 |
| Infiltration capacity coefficient a | 211 | 243 | 84 | 200 |
| Infiltration capacity exponent b | 5.0 | 0.6 | 3.3 | 1.0 |
| Initial depth (mm) | 50 | 50 | 50 | 50 |
| Daily recharge rate (%) | 28 | 0 | 100 | 25 |
| Daily baseflow rate (%) | 27 | 31 | 22 | 3 |
| Daily deep seepage rate (%) | 0 | 0 | 0 | 0 |

**Table 3.8 Pollutant export parameters for split catchment land use (log$^{10}$ values)**

| FLOW TYPE | SURFACE TYPE | TSS log$^{10}$ values | | TP log$^{10}$ values | | TN log$^{10}$ values | |
|---|---|---|---|---|---|---|---|
| | | Mean | St. dev. | Mean | St. dev. | Mean | St. dev. |
| | **Urban residential** | | | | | | |
| Baseflow parameters | Roof | N/A | N/A | N/A | N/A | N/A | N/A |
| | Roads | 1.00 | 0.34 | -0.97 | 0.31 | 0.20 | 0.20 |
| | Ground level | 1.00 | 0.34 | -0.97 | 0.31 | 0.20 | 0.20 |
| Stormflow parameters | Roof | 1.30 | 0.39 | -0.89 | 0.31 | 0.26 | 0.23 |
| | Roads | 2.43 | 0.39 | -0.30 | 0.31 | 0.26 | 0.23 |
| | Ground level | 2.18 | 0.39 | -0.47 | 0.31 | 0.26 | 0.23 |
| | **Industrial** | | | | | | |
| Baseflow parameters | Roof | N/A | N/A | N/A | N/A | N/A | N/A |
| | Roads | 0.78 | 0.45 | -1.11 | 0.48 | 0.14 | 0.20 |
| | Ground level | 0.78 | 0.45 | -1.11 | 0.48 | 0.14 | 0.20 |
| Stormflow parameters | Roof | 1.30 | 0.44 | -0.89 | 0.36 | 0.25 | 0.32 |
| | Roads | 2.43 | 0.44 | -0.30 | 0.36 | 0.25 | 0.32 |
| | Ground level | 1.92 | 0.44 | -0.59 | 0.36 | 0.25 | 0.32 |
| | **Commercial** | | | | | | |
| Baseflow parameters | Roof | N/A | N/A | N/A | N/A | N/A | N/A |
| | Roads | 0.78 | 0.39 | -0.60 | 0.50 | 0.32 | 0.30 |
| | Ground level | 0.78 | 0.39 | -0.60 | 0.50 | 0.32 | 0.30 |
| Stormflow parameters | Roof | 1.30 | 0.38 | -0.89 | 0.34 | 0.37 | 0.34 |
| | Roads | 2.43 | 0.38 | -0.30 | 0.34 | 0.37 | 0.34 |
| | Ground level | 2.16 | 0.38 | -0.39 | 0.34 | 0.37 | 0.34 |

**Table 3.9 Pollutant export parameters for lumped catchment land uses (log$^{10}$ values)**

| LANDUSE | FLOW TYPE | TSS log$^{10}$ values | | TP log$^{10}$ values | | TN log$^{10}$ values | |
|---|---|---|---|---|---|---|---|
| | | Mean | St. dev. | Mean | St. dev. | Mean | St. dev. |
| Urban residential | Baseflow | 1.00 | 0.34 | -0.97 | 0.31 | 0.20 | 0.20 |
| | Stormflow | 2.18 | 0.39 | -0.47 | 0.32 | 0.26 | 0.23 |
| Industrial | Baseflow | 0.78 | 0.45 | -1.11 | 0.48 | 0.14 | 0.20 |
| | Stormflow | 1.92 | 0.44 | -0.59 | 0.36 | 0.25 | 0.32 |
| Commercial | Baseflow | 0.78 | 0.39 | -0.60 | 0.50 | 0.32 | 0.30 |
| | Stormflow | 2.16 | 0.38 | -0.39 | 0.34 | 0.37 | 0.34 |
| Rural residential | Baseflow | 0.53 | 0.24 | -1.54 | 0.38 | -0.52 | 0.39 |
| | Stormflow | 2.26 | 0.51 | -0.56 | 0.28 | 0.32 | 0.30 |
| Forest | Baseflow | 0.51 | 0.28 | -1.79 | 0.28 | -0.59 | 0.22 |
| | Stormflow | 1.90 | 0.20 | -1.10 | 0.22 | -0.075 | 0.24 |
| Agriculture | Baseflow | 1.00 | 0.13 | -1.155 | 0.13 | -0.155 | 0.13 |
| | Stormflow | 2.477 | 0.31 | -0.495 | 0.30 | 0.29 | 0.26 |

Flagstone City - Stage 7

# APPENDIX D

## Rational Method Detailed Calculations

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### Existing Condition Peak Flow Estimates (Rational Method)

| Catchment | Area (ha) | Fi | C10 | C1 | Total Tc (min) | 1 Year Intensity | Q1 |
|---|---|---|---|---|---|---|---|
| EC1 | 4.91 | 0.0 | 0.59 | 0.472 | 29 | 52.0 | 0.33 |
| EC2 | 4.50 | 0.0 | 0.59 | 0.472 | 29 | 52.0 | 0.31 |

Flagstone City - Stage 7

# APPENDIX E

## Pre-Development Flooding Conditions (TUFLOW Results)

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LEGEND

- Site Extents
- Previously Approved Stage 1
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points
- STAGE 7

WATER SURFACE LEVEL (mAHD)

- Above 59.50
- 58.00 to 59.50
- 56.50 to 58.00
- 55.00 to 56.50
- 53.50 to 55.00
- 52.00 to 53.50
- 50.50 to 52.00
- 49.00 to 50.50
- 47.50 to 49.00
- 46.00 to 47.50
- 44.50 to 46.00
- 43.00 to 44.50
- 41.50 to 43.00
- 40.00 to 41.50
- 38.50 to 40.00
- 37.00 to 38.50
- 35.50 to 37.00
- 34.00 to 35.50
- 32.50 to 34.00
- 31.00 to 32.50
- 29.50 to 31.00
- Below 29.50

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Scale 1:30000 (A3)

**FIGURE E1**

# 100 Year ARI - Pre-Development Case (E21e) - Peak Water Surface Levels

Rev: Orig. Date: 01 December 2014

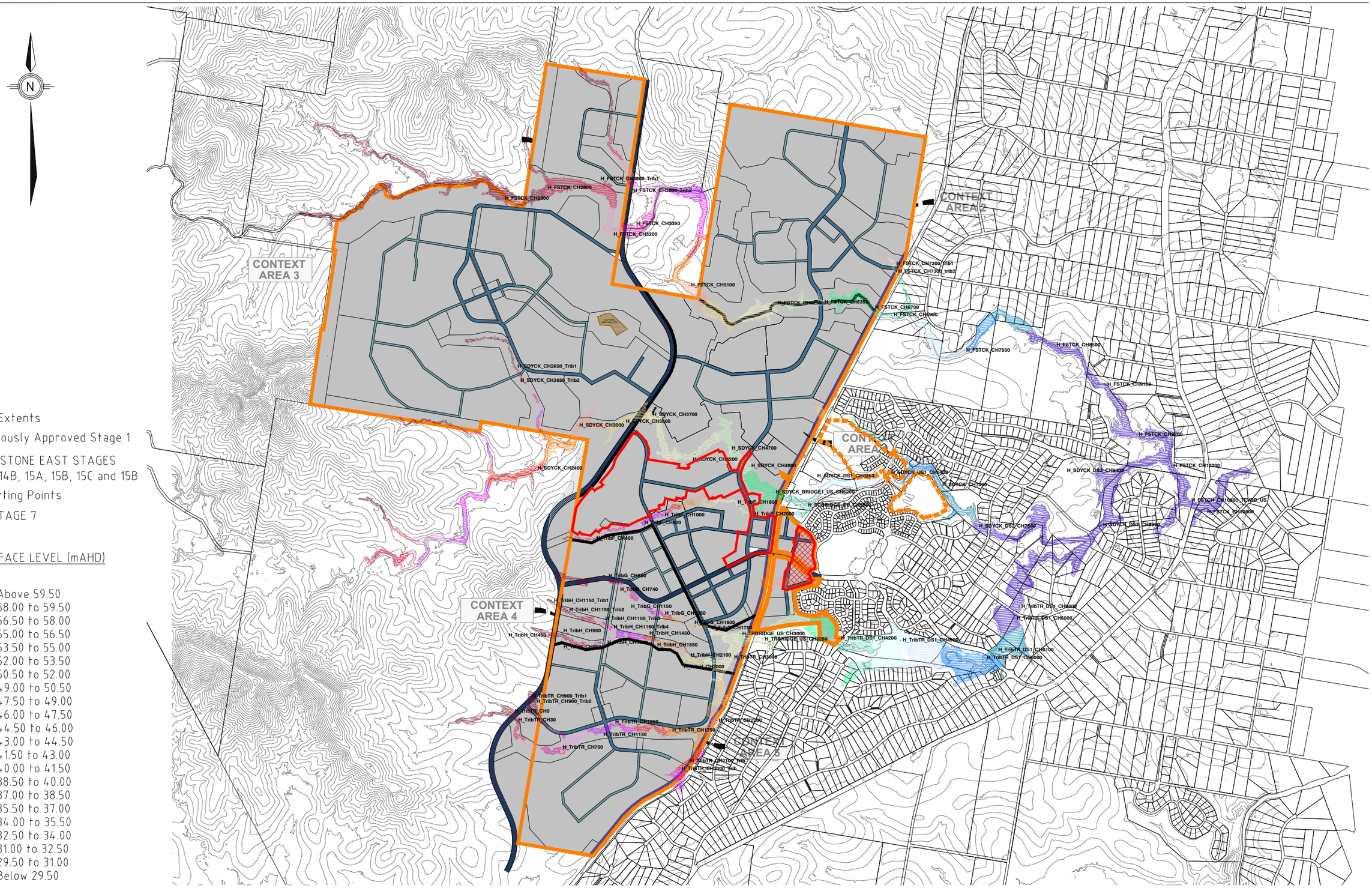
Project No.: 7217/43

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LEGEND

- Site Extents
- Previously Approved Stage 1
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points
- STAGE 7

WATER SURFACE LEVEL (mAHD)

- Above 59.50
- 58.00 to 59.50
- 56.50 to 58.00
- 55.00 to 56.50
- 53.50 to 55.00
- 52.00 to 53.50
- 50.50 to 52.00
- 49.00 to 50.50
- 47.50 to 49.00
- 46.00 to 47.50
- 44.50 to 46.00
- 43.00 to 44.50
- 41.50 to 43.00
- 40.00 to 41.50
- 38.50 to 40.00
- 37.00 to 38.50
- 35.50 to 37.00
- 34.00 to 35.50
- 32.50 to 34.00
- 31.00 to 32.50
- 29.50 to 31.00
- Below 29.50

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**FIGURE E2**

# 50 Year ARI - Pre-Development Case (E21e) - Peak Water Surface Levels

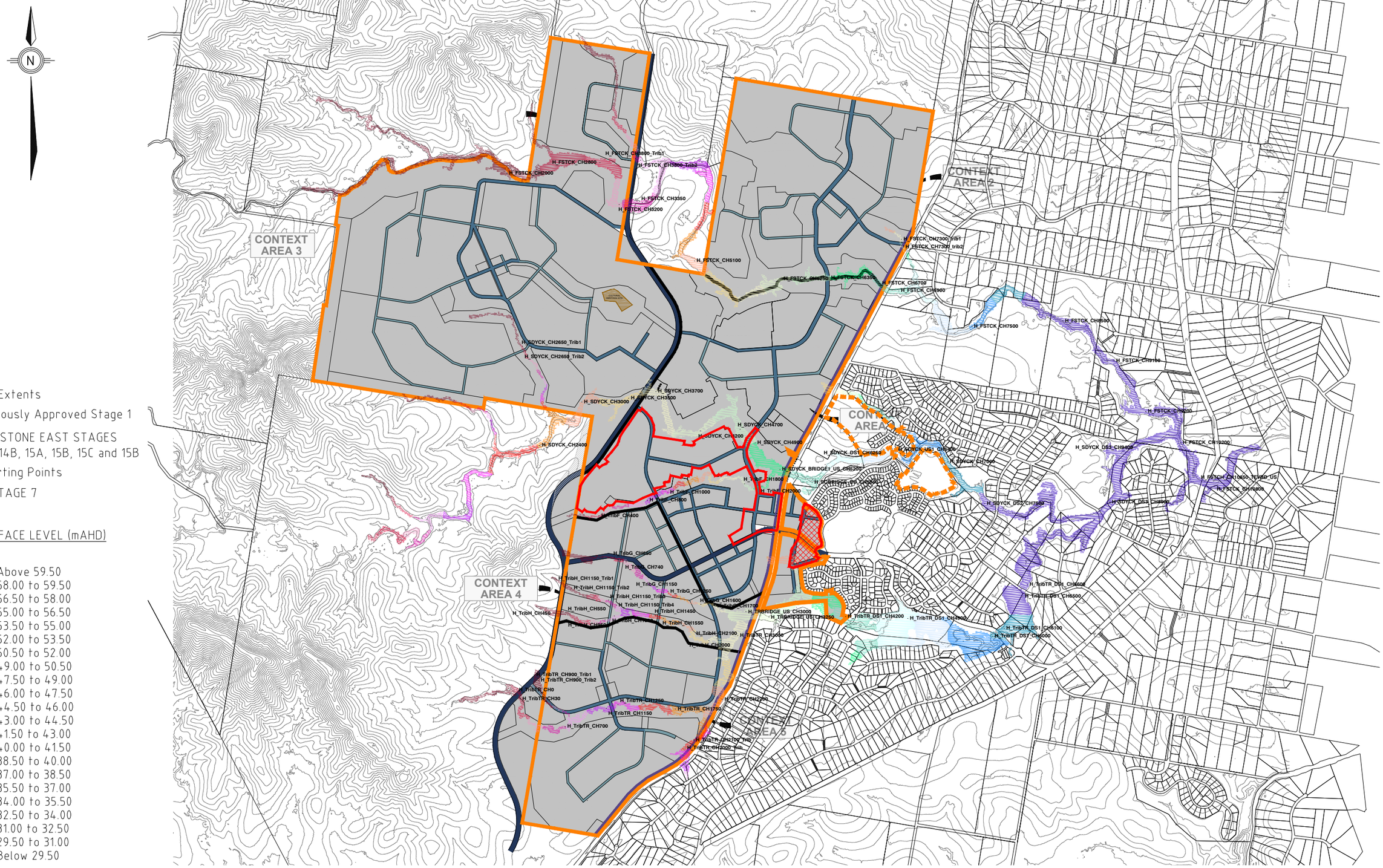
Rev: Orig. Date: 01 December 2014

Project No.: 7217/43

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**FIGURE E3**

# 20 Year ARI - Pre-Development Case (E21e) - Peak Water Surface Levels

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PRINT DATE: 03 December, 2014 - 10:08am




LEGEND

- Site Extents
- Previously Approved Stage 1
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points
- STAGE 7

WATER SURFACE LEVEL (mAHD)

- Above 59.50
- 58.00 to 59.50
- 56.50 to 58.00
- 55.00 to 56.50
- 53.50 to 55.00
- 52.00 to 53.50
- 50.50 to 52.00
- 49.00 to 50.50
- 47.50 to 49.00
- 46.00 to 47.50
- 44.50 to 46.00
- 43.00 to 44.50
- 41.50 to 43.00
- 40.00 to 41.50
- 38.50 to 40.00
- 37.00 to 38.50
- 35.50 to 37.00
- 34.00 to 35.50
- 32.50 to 34.00
- 31.00 to 32.50
- 29.50 to 31.00
- Below 29.50



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Scale 1:30000 (A3)

**FIGURE E4**

## 10 Year ARI - Pre-Development Case (E21e) - Peak Water Surface Levels

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LEGEND

- Site Extents
- Previously Approved Stage 1
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points
- STAGE 7

WATER SURFACE LEVEL (mAHD)

- Above 59.50
- 58.00 to 59.50
- 56.50 to 58.00
- 55.00 to 56.50
- 53.50 to 55.00
- 52.00 to 53.50
- 50.50 to 52.00
- 49.00 to 50.50
- 47.50 to 49.00
- 46.00 to 47.50
- 44.50 to 46.00
- 43.00 to 44.50
- 41.50 to 43.00
- 40.00 to 41.50
- 38.50 to 40.00
- 37.00 to 38.50
- 35.50 to 37.00
- 34.00 to 35.50
- 32.50 to 34.00
- 31.00 to 32.50
- 29.50 to 31.00
- Below 29.50

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Scale 1:30000 (A3)

**FIGURE E5**

# 5 Year ARI - Pre-Development Case (E21e) - Peak Water Surface Levels

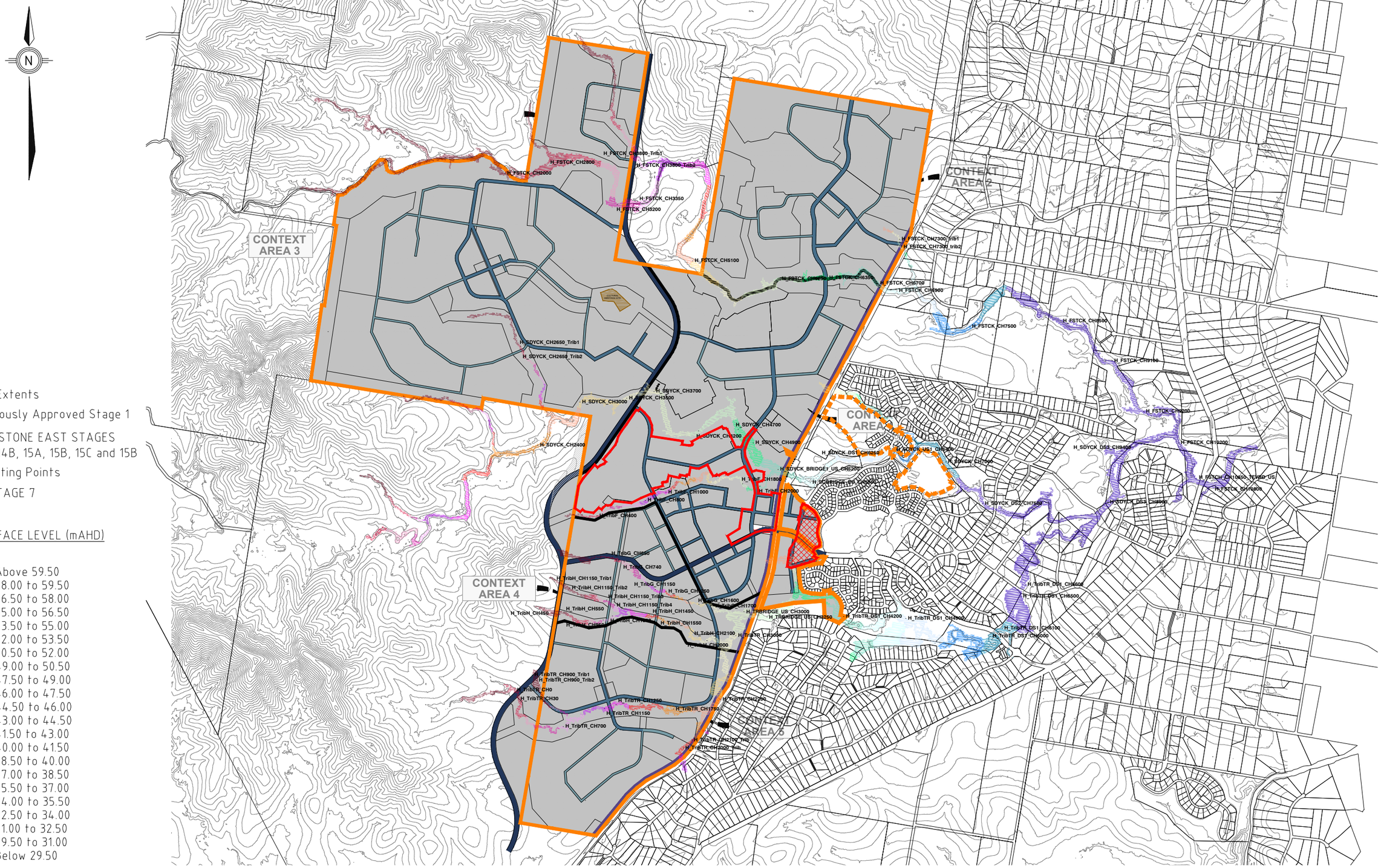
Rev: Orig. Date: 01 December 2014

Project No.: 7217/43

Peet Flagstone City Pty Ltd

CAD FILE: O:\7217-43\FlagstoneEastCommercial\Acad\Figures\Appendix E.dwg
XREF's: Existing Contours; WSL_Reporting points_All_Points_moved; E21eTuflow_Results_20140901; 110056-262-STRUCTURE_OPT2L_grey

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Scale 1:30000 (A3)

**FIGURE E6**

# 2 Year ARI - Pre-Development Case (E21e) - Peak Water Surface Levels

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XREF's: Existing Contours; WSL_Reporting points_All_Points_moved; E21eTuflow_Results_20140901; 110056-262-STRUCTURE_OPT2L_grey

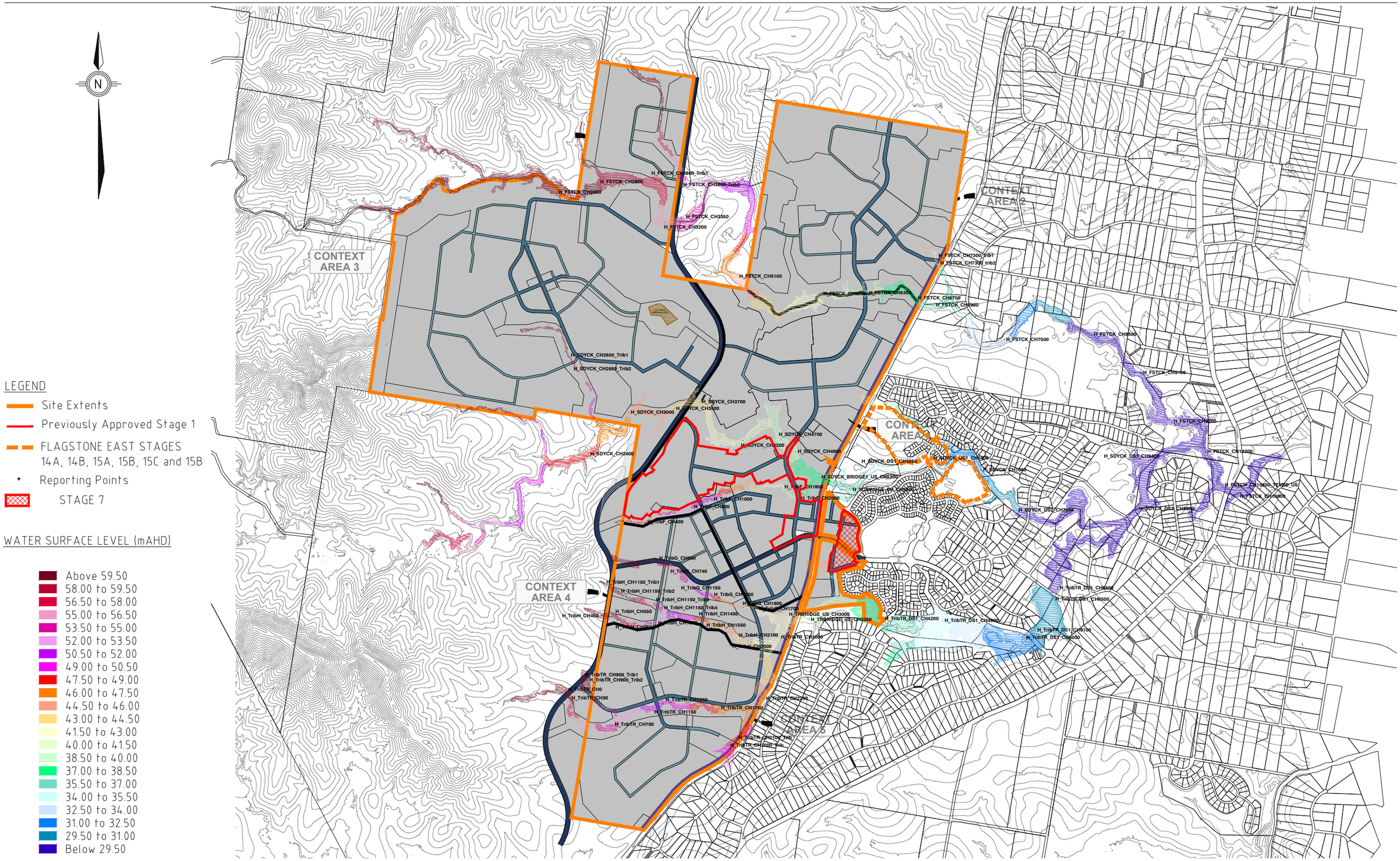
PRINT DATE: 03 December, 2014 - 10:12am

Flagstone City - Stage 7

# APPENDIX F

## Post-Development Flooding Conditions (TUFLOW Results)

Cardno
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LEGEND

- Site Extents
- Previously Approved Stage 1
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points
- STAGE 7

WATER SURFACE LEVEL (mAHD)

- Above 59.50
- 58.00 to 59.50
- 56.50 to 58.00
- 55.00 to 56.50
- 53.50 to 55.00
- 52.00 to 53.50
- 50.50 to 52.00
- 49.00 to 50.50
- 47.50 to 49.00
- 46.00 to 47.50
- 44.50 to 46.00
- 43.00 to 44.50
- 41.50 to 43.00
- 40.00 to 41.50
- 38.50 to 40.00
- 37.00 to 38.50
- 35.50 to 37.00
- 34.00 to 35.50
- 32.50 to 34.00
- 31.00 to 32.50
- 29.50 to 31.00
- Below 29.50

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300 0 300 600 900 1200 1500m
1:30,000

Scale 1:30000 (A3)

**FIGURE F1**

# 100 Year ARI - Post-Development Case (EC_DU03M) - Peak Water Surface Levels

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LEGEND

- Site Extents
- Previously Approved Stage 1
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points
- STAGE 7

WATER SURFACE LEVEL (mAHD)

- Above 59.50
- 58.00 to 59.50
- 56.50 to 58.00
- 55.00 to 56.50
- 53.50 to 55.00
- 52.00 to 53.50
- 50.50 to 52.00
- 49.00 to 50.50
- 47.50 to 49.00
- 46.00 to 47.50
- 44.50 to 46.00
- 43.00 to 44.50
- 41.50 to 43.00
- 40.00 to 41.50
- 38.50 to 40.00
- 37.00 to 38.50
- 35.50 to 37.00
- 34.00 to 35.50
- 32.50 to 34.00
- 31.00 to 32.50
- 29.50 to 31.00
- Below 29.50



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Scale 1:30000 (A3)

**FIGURE F2**

# 50 Year ARI - Post-Development Case (EC_DU03M) - Peak Water Surface Levels

Rev: Orig. Date: 01 December 2014

Project No.: 7217/43

Peet Flagstone City Pty Ltd

CAD FILE: O:\7217-43\FlagstoneEastCommercial\Acad\Figures\Appendix F.dwg
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PRINT DATE: 03 December, 2014 - 10:14am




LEGEND

- Site Extents
- Previously Approved Stage 1
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points
- STAGE 7

WATER SURFACE LEVEL (mAHD)

- Above 59.50
- 58.00 to 59.50
- 56.50 to 58.00
- 55.00 to 56.50
- 53.50 to 55.00
- 52.00 to 53.50
- 50.50 to 52.00
- 49.00 to 50.50
- 47.50 to 49.00
- 46.00 to 47.50
- 44.50 to 46.00
- 43.00 to 44.50
- 41.50 to 43.00
- 40.00 to 41.50
- 38.50 to 40.00
- 37.00 to 38.50
- 35.50 to 37.00
- 34.00 to 35.50
- 32.50 to 34.00
- 31.00 to 32.50
- 29.50 to 31.00
- Below 29.50



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300 0 300 600 900 1200 1500m
1:30,000

Scale 1:30000 (A3)

**FIGURE F3**

# 20 Year ARI - Post-Development Case (EC_DU03M) - Peak Water Surface Levels

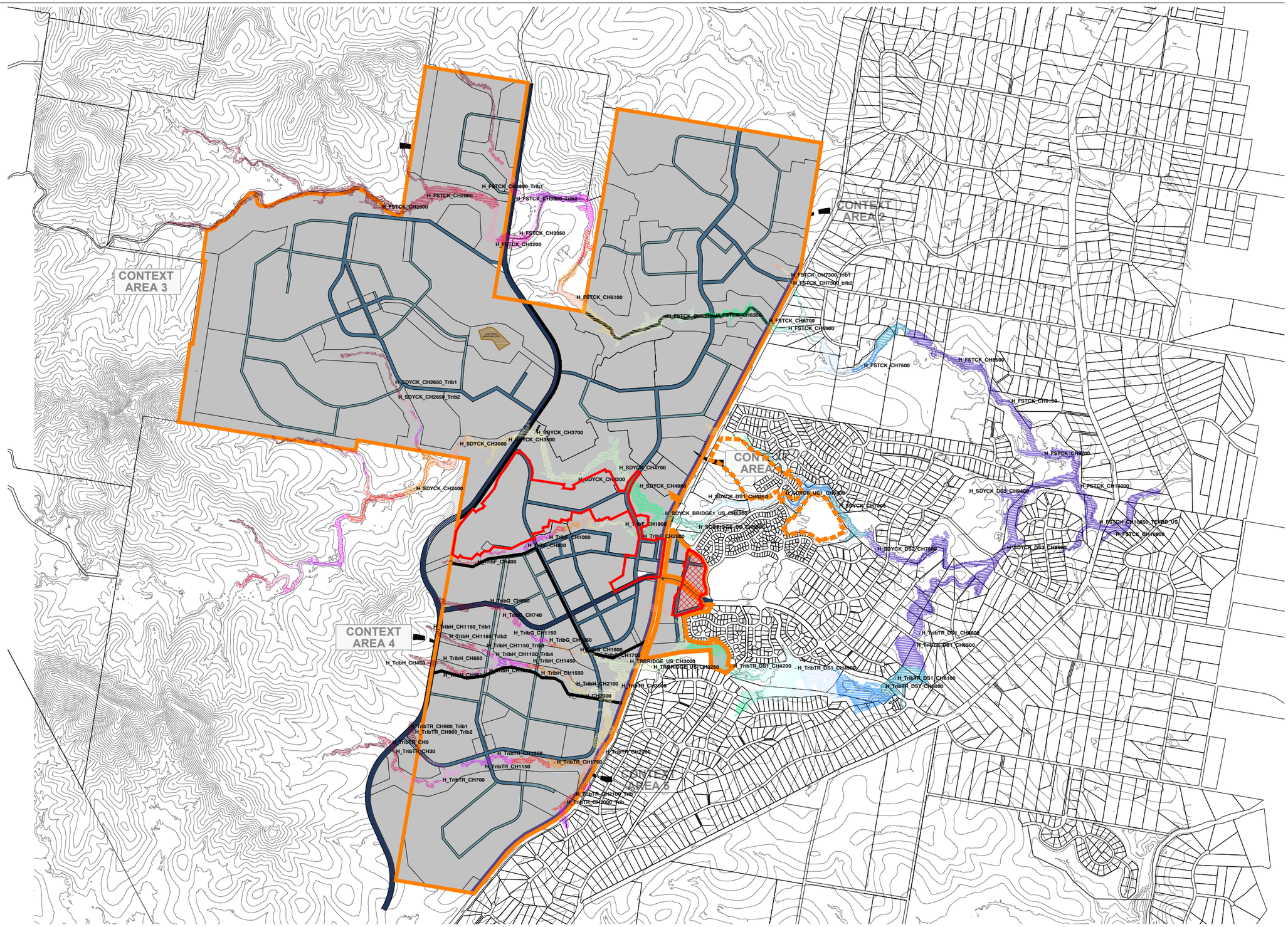
Rev: Orig. Date: 01 December 2014

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LEGEND

- Site Extents
- Previously Approved Stage 1
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points
- STAGE 7

WATER SURFACE LEVEL (mAHD)

- Above 59.50
- 58.00 to 59.50
- 56.50 to 58.00
- 55.00 to 56.50
- 53.50 to 55.00
- 52.00 to 53.50
- 50.50 to 52.00
- 49.00 to 50.50
- 47.50 to 49.00
- 46.00 to 47.50
- 44.50 to 46.00
- 43.00 to 44.50
- 41.50 to 43.00
- 40.00 to 41.50
- 38.50 to 40.00
- 37.00 to 38.50
- 35.50 to 37.00
- 34.00 to 35.50
- 32.50 to 34.00
- 31.00 to 32.50
- 29.50 to 31.00
- Below 29.50

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300 0 300 600 900 1200 1500m
1:30,000

Scale 1:30000 (A3)

**FIGURE F4**

# 10 Year ARI - Post-Development Case (EC_DU03M) - Peak Water Surface Levels

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LEGEND

- Site Extents
- Previously Approved Stage 1
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points
- STAGE 7

WATER SURFACE LEVEL (mAHD)

- Above 59.50
- 58.00 to 59.50
- 56.50 to 58.00
- 55.00 to 56.50
- 53.50 to 55.00
- 52.00 to 53.50
- 50.50 to 52.00
- 49.00 to 50.50
- 47.50 to 49.00
- 46.00 to 47.50
- 44.50 to 46.00
- 43.00 to 44.50
- 41.50 to 43.00
- 40.00 to 41.50
- 38.50 to 40.00
- 37.00 to 38.50
- 35.50 to 37.00
- 34.00 to 35.50
- 32.50 to 34.00
- 31.00 to 32.50
- 29.50 to 31.00
- Below 29.50



300 0 300 600 900 1200 1500m
1:30,000

Scale 1:30000 (A3)

**FIGURE F5**

# 5 Year ARI - Post-Development Case (EC_DU03M) - Peak Water Surface Levels

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LEGEND

- Site Extents
- Previously Approved Stage 1
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points
- STAGE 7

WATER SURFACE LEVEL (mAHD)

- Above 59.50
- 58.00 to 59.50
- 56.50 to 58.00
- 55.00 to 56.50
- 53.50 to 55.00
- 52.00 to 53.50
- 50.50 to 52.00
- 49.00 to 50.50
- 47.50 to 49.00
- 46.00 to 47.50
- 44.50 to 46.00
- 43.00 to 44.50
- 41.50 to 43.00
- 40.00 to 41.50
- 38.50 to 40.00
- 37.00 to 38.50
- 35.50 to 37.00
- 34.00 to 35.50
- 32.50 to 34.00
- 31.00 to 32.50
- 29.50 to 31.00
- Below 29.50

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300 0 300 600 900 1200 1500m
1:30,000

Scale 1:30000 (A3)

**FIGURE F6**

# 2 Year ARI - Post-Development Case (EC_DU03M) - Peak Water Surface Levels

Project No.: 7217/43

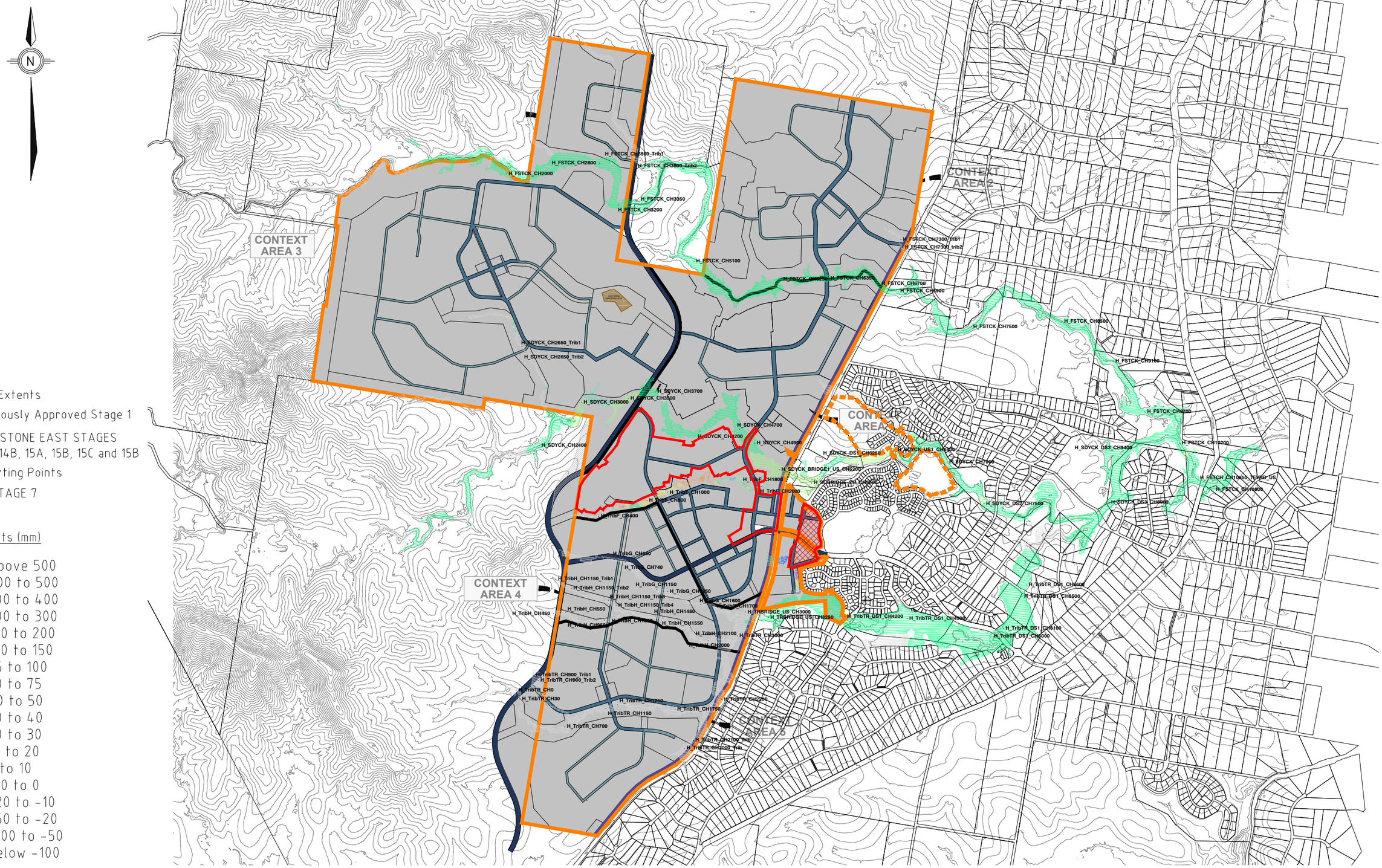
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Flagstone City - Stage 7

# APPENDIX G

## Pre-Development Predicted Impacts (TUFLOW Results)

Cardno
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LEGEND

- Site Extents
- Previously Approved Stage 1
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points
- STAGE 7

Flood Impacts (mm)

- Above 500
- 400 to 500
- 300 to 400
- 200 to 300
- 150 to 200
- 100 to 150
- 75 to 100
- 50 to 75
- 40 to 50
- 30 to 40
- 20 to 30
- 10 to 20
- 0 to 10
- -10 to 0
- -20 to -10
- -50 to -20
- -100 to -50
- Below -100

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300 0 300 600 900 1200 1500m
1:30,000

Scale 1:30000 (A3)

**FIGURE G1**

# 100 Year ARI - Post-Development Case (EC_DU03M) - Flood Impacts

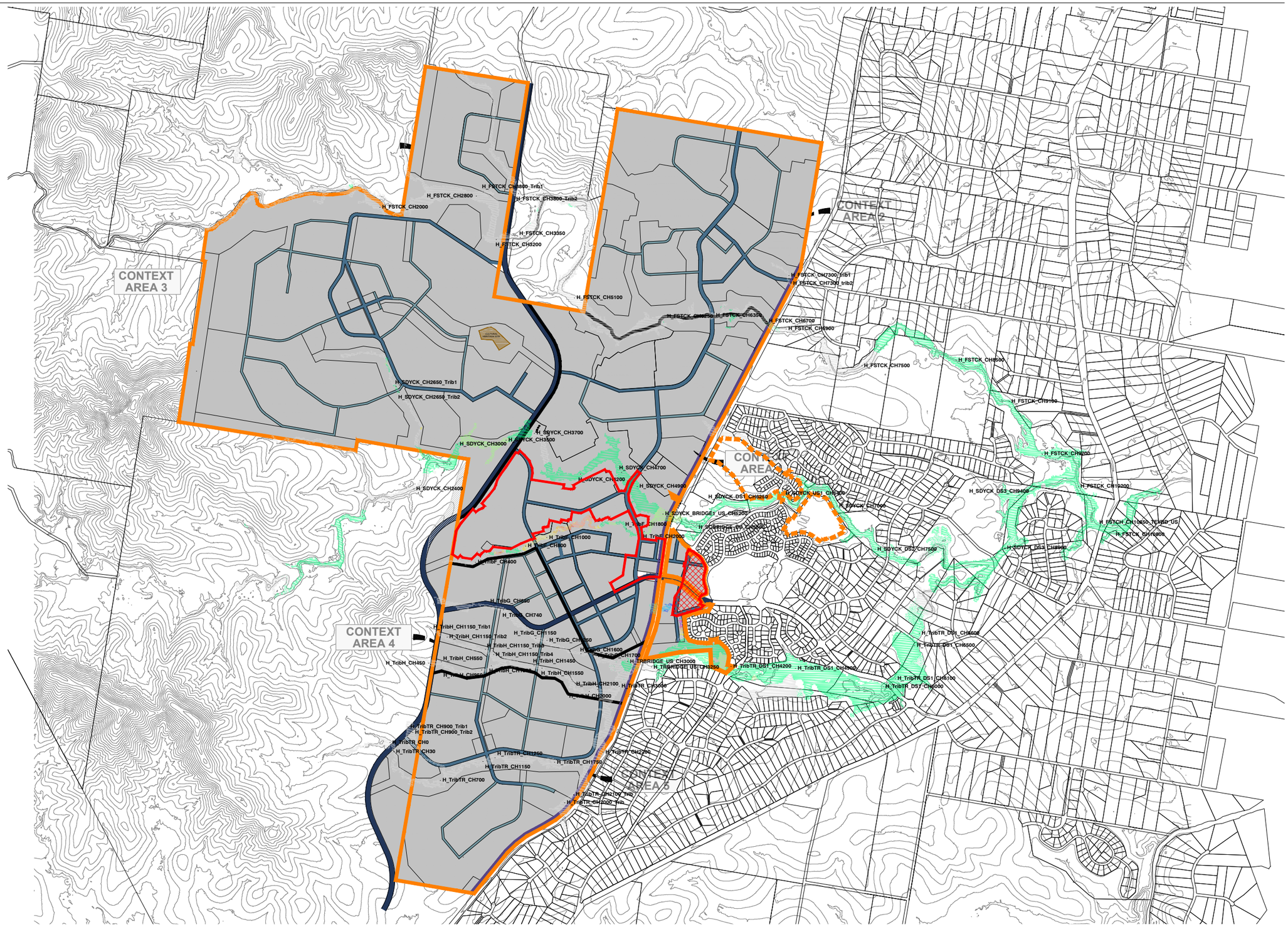
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Scale 1:30000 (A3)

**FIGURE G2**

# 50 Year ARI - Post-Development Case (EC_DU03M) - Flood Impacts

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Project No.: 7217/43

Peet Flagstone City Pty Ltd

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LEGEND

- Site Extents
- Previously Approved Stage 1
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points
- STAGE 7

Flood Impacts (mm)

- Above 500
- 400 to 500
- 300 to 400
- 200 to 300
- 150 to 200
- 100 to 150
- 75 to 100
- 50 to 75
- 40 to 50
- 30 to 40
- 20 to 30
- 10 to 20
- 0 to 10
- -10 to 0
- -20 to -10
- -50 to -20
- -100 to -50
- Below -100

CONTEXT AREA 2
CONTEXT AREA 3
CONTEXT AREA 4
CONTEXT AREA 5

H_FSTCK_CH3800_Trib1
H_FSTCK_CH3800_Trib2
H_FSTCK_CH2800
H_FSTCK_CH2000
H_FSTCK_CH3350
H_FSTCK_CH3200
H_FSTCK_CH5100
H_FSTCK_CH7300_trib1
H_FSTCK_CH7300_trib2
H_FSTCK_CH6350
H_FSTCK_CH6700
H_FSTCK_CH6900
H_FSTCK_CH7500
H_FSTCK_CH8500
H_FSTCK_CH9100
H_FSTCK_CH9200
H_FSTCK_CH10200
H_SDYCK_CH2650_Trib1
H_SDYCK_CH2650_Trib2
H_SDYCK_CH3700
H_SDYCK_CH3500
H_SDYCK_CH3000
H_SDYCK_CH4700
H_SDYCK_CH1200
H_SDYCK_CH4900
H_SDYCK_CH2400
H_SDYCK_DS1_CH6250
H_SDYCK_US1_CH6300
H_SDYCK_CH7000
H_SDYCK_BRIDGE1_US_CH6200
H_SDYCK_BRIDGE1_DS_CH6200
H_SDYCK_DS3_CH9400
H_SDYCK_DS3_CH7500
H_SDYCK_DS3_CH8900
H_FSTCK_CH10850_TRIB_US
H_FSTCK_CH10809
H_TribF_CH1800
H_TribF_CH2000
H_TribF_CH1000
H_TribF_CH800
H_TribF_CH400
H_TribG_CH650
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H_TribH_CH1150_Trib3
H_TribG_CH1600
H_TribH_CH1150_Trib4
H_TribG_CH1700
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H_TRBRIDGE_US_CH3250
H_TribH_CH450
H_TribH_CH550
H_TribH_CH1450
H_TribH_CH1550
H_TribH_CH2100
H_TribTR_CH3000
H_TribH_CH2000
H_TribTR_DS1_CH4200
H_TribTR_DS1_CH4900
H_TribTR_DS1_CH8100
H_TribTR_DST_CH6000
H_TribTR_DS1_CH6600
H_TribTR_DS1_CH8500
H_TribTR_CH900_Trib1
H_TribTR_CH900_Trib2
H_TribTR_CH0
H_TribTR_CH30
H_TribTR_CH1250
H_TribTR_CH1750
H_TribTR_CH4200
H_TribTR_CH1150
H_TribTR_CH700
H_TribTR_CH2100_Trib2
H_TribTR_CH2000_Trib

300 0 300 600 900 1200 1500m
1:30,000

Scale 1:30000 (A3)

**FIGURE G3**

## 20 Year ARI - Post-Development Case (EC_DU03M) - Flood Impacts

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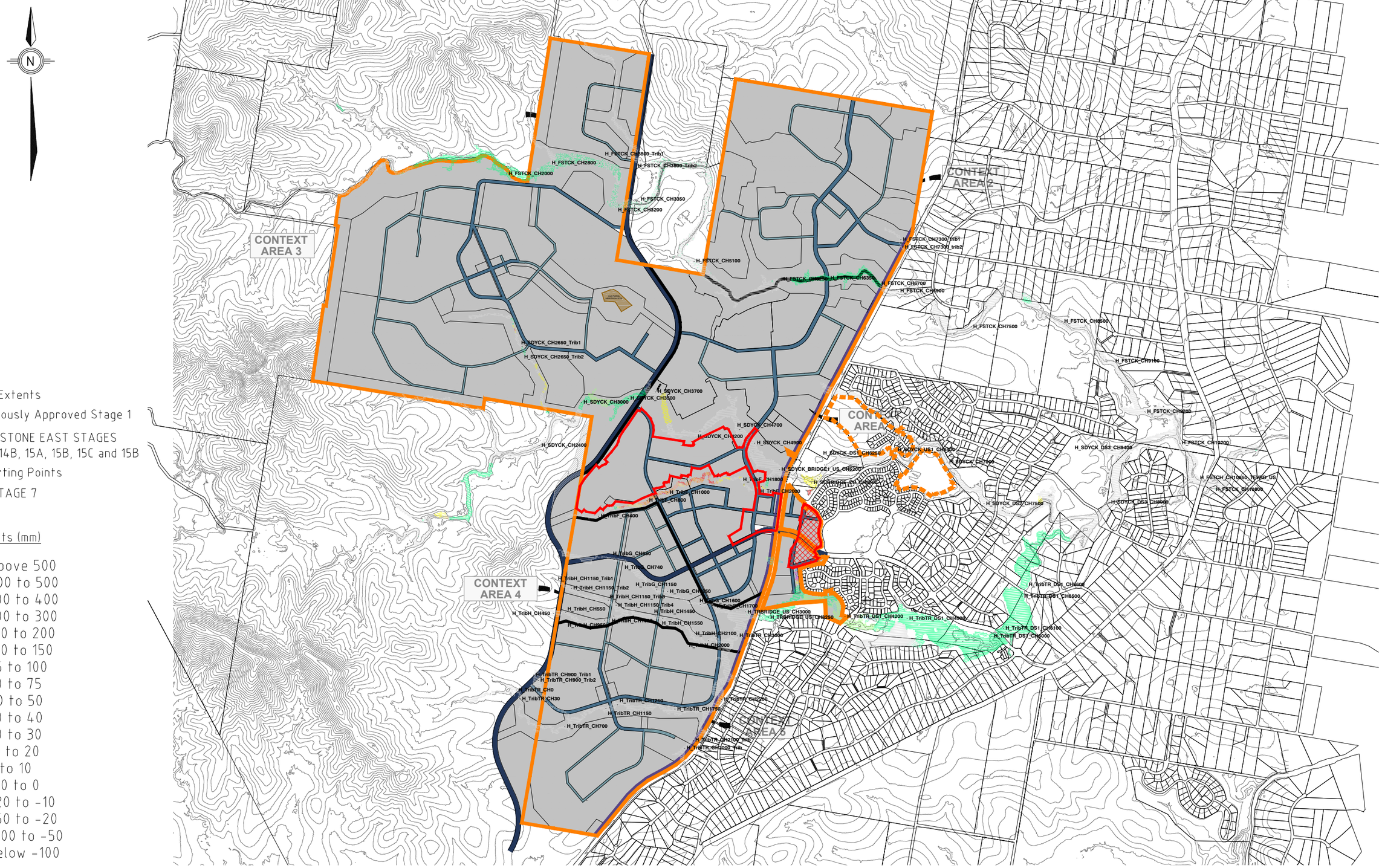
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Cardno




LEGEND

- Site Extents
- Previously Approved Stage 1
- FLAGSTONE EAST STAGES 14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points
- STAGE 7

Flood Impacts (mm)

- Above 500
- 400 to 500
- 300 to 400
- 200 to 300
- 150 to 200
- 100 to 150
- 75 to 100
- 50 to 75
- 40 to 50
- 30 to 40
- 20 to 30
- 10 to 20
- 0 to 10
- -10 to 0
- -20 to -10
- -50 to -20
- -100 to -50
- Below -100

300 0 300 600 900 1200 1500m
1:30,000

Scale 1:30000 (A3)

**FIGURE G4**

# 10 Year ARI - Post-Development Case (EC_DU03M) - Flood Impacts

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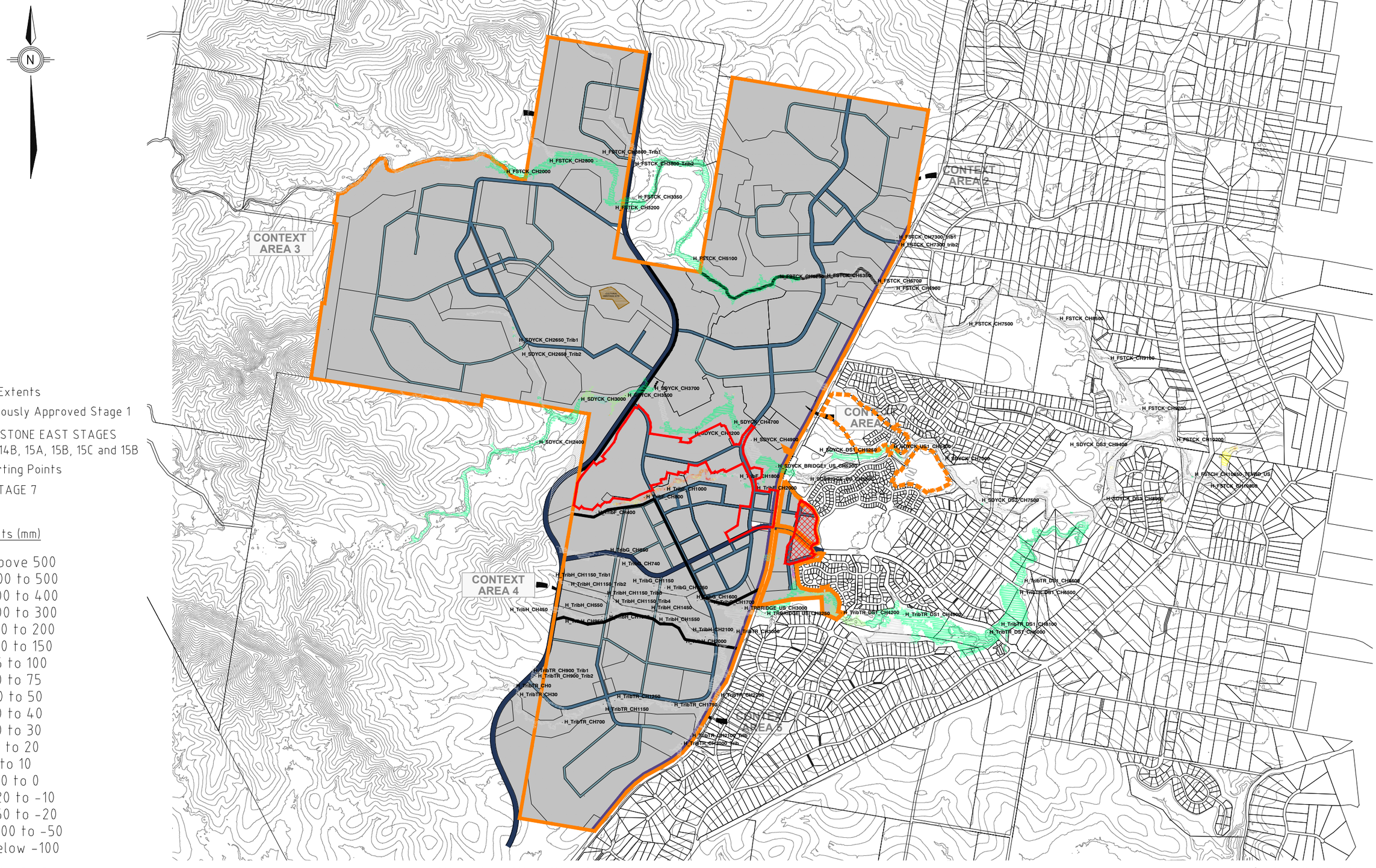
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Scale 1:30000 (A3)

**FIGURE G5**

# 5 Year ARI - Post-Development Case (EC_DU03M) - Flood Impacts

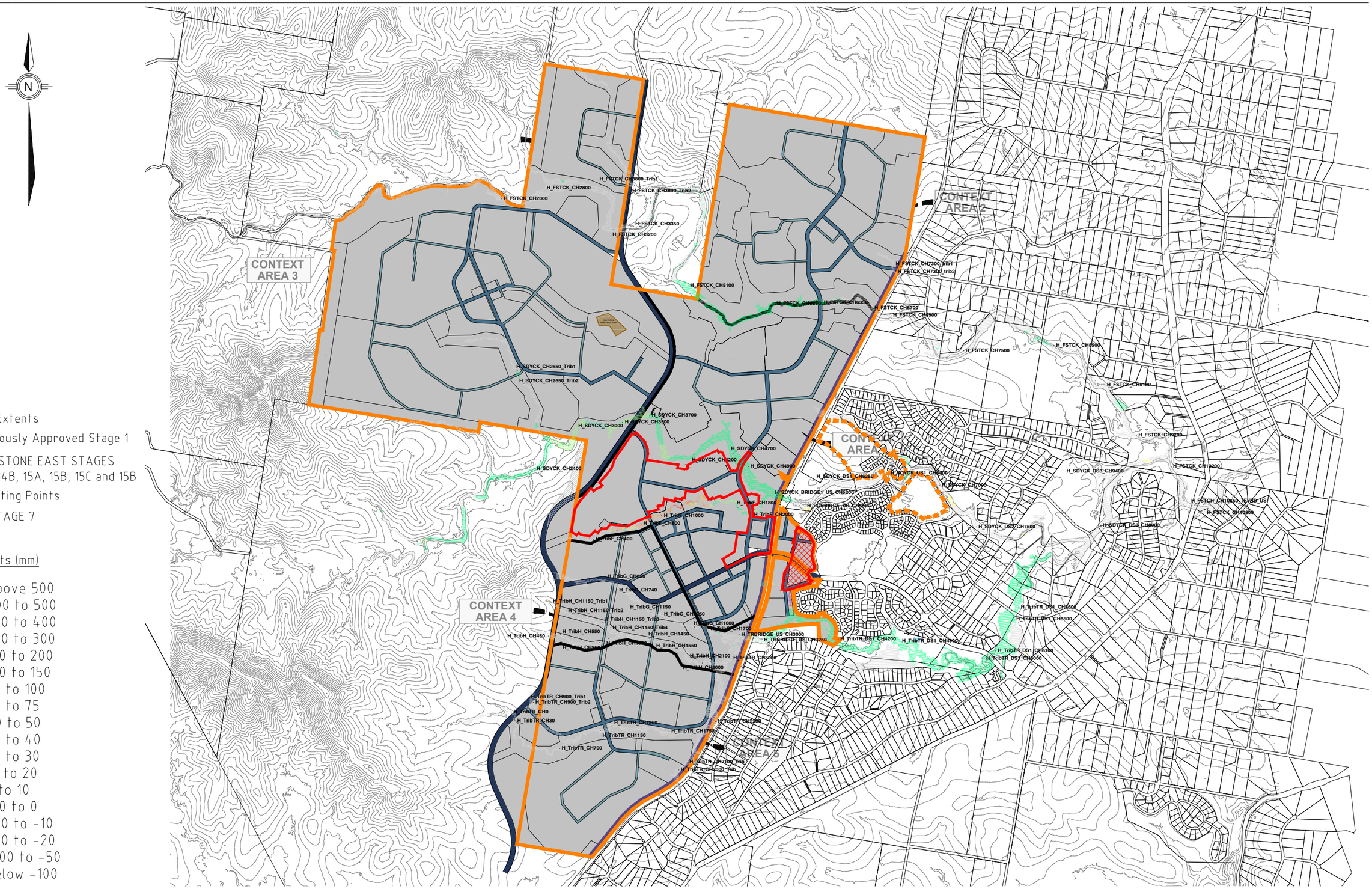
Rev: Orig. Date: 01 December 2014

Project No.: 7217/43

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CAD FILE: G:\7217-43\FlagstoneEastCommercial\Acad\Figures\Appendix G.dwg
XREF's: Existing Contours; WSL_Reporting points_All_Points_moved; E21eTuflow_Results_20140901; 110056-262-STRUCTURE_OPT2L_grey

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**FIGURE G6**

# 2 Year ARI - Post-Development Case (EC_DU03M) - Flood Impacts

Rev: Orig. Date: 01 December 2014

Project No.: 7217/43

Peet Flagstone City Pty Ltd

CAD FILE: O:\7217-43\FlagstoneEastCommercial\Acad\Figures\Appendix G.dwg
XREF's: Existing Contours; WSL_Reporting points_All_Points_moved; E21eTuflow_Results_20140901; 110056-262-STRUCTURE_OPT2L_grey

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Flagstone City - Stage 7

# APPENDIX H

## Post-Development Predicted Impacts (TUFLoW Detailed Results)

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Table H1

Reporting Points - Peak Water Surface Levels and Impacts

Location: O:\7217-43\FlagstoneEastCommercial\Excel\Appendix EC Time Series\Reporting Points Peak WSL_E21e_EC.xlsx

| | Existing Peak Water Surface Levels (mAHD) | | | | | | Developed Peak Water Surface Levels (mAHD) | | | | | | Impact (m) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reporting point/ARI (Years) | 100 | 50 | 20 | 10 | 5 | 2 | 100 | 50 | 20 | 10 | 5 | 2 | 100 | 50 | 20 | 10 | 5 | 2 |
| H_SDYCK_DS3_CH9400 | 24.46 | 24.22 | 23.88 | 23.59 | 23.36 | 22.86 | 24.45 | 24.216 | 23.88 | 23.59 | 23.36 | 22.86 | -0.004 | -0.002 | -0.003 | 0.001 | -0.001 | 0.001 |
| H_SDYCK_DS3_CH8900 | 25.91 | 25.73 | 25.45 | 25.21 | 25.01 | 24.62 | 25.91 | 25.73 | 25.45 | 25.22 | 25.01 | 24.62 | -0.003 | 0.000 | -0.002 | 0.001 | 0.001 | 0.001 |
| H_SDYCK_DS2_CH7500 | 29.59 | 29.38 | 29.15 | 28.89 | 28.75 | 28.29 | 29.58 | 29.38 | 29.14 | 28.90 | 28.76 | 28.29 | -0.009 | 0.000 | -0.001 | 0.005 | 0.002 | 0.000 |
| H_SDYCK_CH7000 | 31.26 | 31.06 | 30.81 | 30.62 | 30.38 | 30.02 | 31.25 | 31.06 | 30.81 | 30.63 | 30.38 | 30.03 | -0.007 | 0.000 | -0.001 | 0.005 | 0.001 | 0.005 |
| H_SDYCK_US1_CH6400 | 33.11 | 32.78 | 32.58 | 32.30 | 32.19 | 31.68 | 33.10 | 32.77 | 32.58 | 32.30 | 32.19 | 31.68 | -0.006 | -0.005 | -0.001 | 0.003 | 0.000 | 0.001 |
| H_SDYCK_DS1_CH6250 | 34.12 | 33.94 | 33.71 | 33.40 | 33.20 | 32.76 | 34.11 | 33.94 | 33.70 | 33.41 | 33.20 | 32.76 | -0.011 | -0.005 | -0.002 | 0.008 | 0.001 | 0.001 |
| H_SCBRIDGE_DS_CH5550 | 36.29 | 36.08 | 35.88 | 35.70 | 35.52 | 35.29 | 36.28 | 36.08 | 35.88 | 35.72 | 35.52 | 35.29 | -0.009 | -0.002 | 0.001 | 0.017 | 0.001 | 0.000 |
| H_SDYCK_BRIDGE1_US_CH5200 | 37.67 | 37.46 | 37.20 | 36.98 | 36.81 | 36.44 | 37.66 | 37.45 | 37.20 | 36.98 | 36.81 | 36.44 | -0.013 | -0.012 | -0.003 | 0.000 | 0.001 | -0.002 |
| H_SDYCK_CH4900 | 38.89 | 38.70 | 38.48 | 38.30 | 38.15 | 37.87 | 38.88 | 38.70 | 38.48 | 38.30 | 38.16 | 37.87 | -0.004 | -0.007 | -0.002 | 0.002 | 0.001 | -0.001 |
| H_SDYCK_CH4700 | 39.41 | 39.22 | 38.98 | 38.79 | 38.65 | 38.34 | 39.40 | 39.21 | 38.98 | 38.80 | 38.65 | 38.34 | -0.004 | -0.006 | -0.003 | 0.002 | 0.001 | -0.002 |
| H_SDYCK_CH4200 | 41.19 | 40.97 | 40.67 | 40.38 | 40.18 | 39.81 | 41.19 | 40.96 | 40.67 | 40.39 | 40.18 | 39.81 | -0.003 | -0.011 | -0.002 | 0.002 | 0.000 | -0.002 |
| H_SDYCK_CH3700 | 43.19 | 42.93 | 42.59 | 42.34 | 42.09 | 41.65 | 43.20 | 42.92 | 42.59 | 42.35 | 42.09 | 41.64 | 0.005 | -0.004 | -0.001 | 0.005 | 0.001 | -0.003 |
| H_SDYCK_CH3500 | 44.10 | 43.85 | 43.53 | 43.26 | 43.04 | 42.63 | 44.09 | 43.83 | 43.51 | 43.26 | 43.04 | 42.62 | -0.009 | -0.016 | -0.013 | -0.008 | -0.009 | -0.013 |
| H_SDYCK_CH3000 | 45.84 | 45.57 | 45.18 | 44.93 | 44.76 | 44.32 | 45.84 | 45.56 | 45.17 | 44.93 | 44.75 | 44.32 | -0.007 | -0.005 | -0.011 | -0.002 | -0.005 | -0.007 |
| H_SDYCK_CH2650_Trib1 | 59.70 | 59.70 | 59.70 | 59.70 | 59.70 | 59.70 | 59.70 | 59.70 | 59.70 | 59.70 | 59.70 | 59.70 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| H_SDYCK_CH2650_Trib2 | 57.40 | 57.27 | 57.17 | 57.21 | 57.16 | 57.07 | 57.40 | 57.31 | 57.19 | 57.21 | 57.16 | 57.07 | 0.000 | 0.042 | 0.014 | 0.000 | 0.000 | 0.000 |
| H_SDYCK_CH2400 | 48.05 | 47.79 | 47.45 | 47.19 | 46.97 | 46.51 | 48.05 | 47.79 | 47.45 | 47.19 | 46.97 | 46.51 | 0.001 | 0.002 | 0.000 | -0.002 | 0.000 | 0.000 |
| H_FSTCK_CH10800 | 21.74 | 21.47 | 21.09 | 20.76 | 20.47 | 19.91 | 21.74 | 21.47 | 21.09 | 20.76 | 20.47 | 19.91 | -0.004 | -0.001 | -0.003 | 0.001 | 0.001 | -0.001 |
| H_FSTCK_CH10200 | 23.20 | 22.94 | 22.60 | 22.29 | 22.01 | 21.37 | 23.19 | 22.94 | 22.60 | 22.29 | 22.01 | 21.37 | -0.003 | -0.001 | -0.003 | 0.001 | 0.000 | 0.000 |
| H_FSTCK_CH9700 | 24.38 | 24.20 | 23.96 | 23.72 | 23.52 | 23.20 | 24.38 | 24.20 | 23.96 | 23.72 | 23.52 | 23.20 | -0.002 | 0.000 | -0.001 | 0.000 | 0.000 | 0.001 |
| H_FSTCK_CH9100 | 26.07 | 25.89 | 25.64 | 25.42 | 25.27 | 24.91 | 26.07 | 25.89 | 25.64 | 25.42 | 25.27 | 24.91 | 0.000 | 0.000 | -0.001 | 0.000 | 0.000 | 0.000 |
| H_FSTCK_CH8500 | 28.52 | 28.29 | 28.03 | 27.78 | 27.56 | 27.13 | 28.52 | 28.29 | 28.03 | 27.78 | 27.56 | 27.13 | 0.000 | 0.000 | -0.001 | 0.000 | 0.000 | 0.000 |
| H_FSTCK_CH7500 | 32.83 | 32.61 | 32.32 | 32.06 | 31.83 | 31.45 | 32.83 | 32.61 | 32.32 | 32.06 | 31.83 | 31.45 | 0.000 | 0.000 | -0.001 | 0.000 | 0.000 | 0.000 |
| H_FSTCK_CH7300_trib1 | 41.88 | 41.72 | 41.62 | 41.57 | 41.52 | 41.42 | 41.88 | 41.72 | 41.62 | 41.57 | 41.52 | 41.42 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| H_FSTCK_CH7300_trib2 | 40.70 | 40.65 | 40.41 | 40.36 | 40.33 | 40.28 | 40.70 | 40.65 | 40.41 | 40.36 | 40.33 | 40.28 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| H_FSTCK_CH6900 | 36.33 | 36.07 | 35.76 | 35.49 | 35.24 | 34.78 | 36.33 | 36.07 | 35.76 | 35.49 | 35.24 | 34.79 | 0.000 | 0.000 | -0.001 | 0.001 | 0.000 | 0.001 |
| H_FSTCK_CH6700 | 37.12 | 36.85 | 36.53 | 36.26 | 36.02 | 35.54 | 37.12 | 36.85 | 36.53 | 36.27 | 36.02 | 35.55 | 0.000 | 0.000 | -0.001 | 0.000 | 0.001 | 0.001 |
| H_FSTCK_CH6350 | 39.19 | 38.94 | 38.57 | 38.29 | 38.05 | 37.58 | 39.19 | 38.94 | 38.57 | 38.29 | 38.05 | 37.58 | 0.000 | -0.002 | -0.001 | -0.001 | 0.001 | 0.001 |
| H_FSTCK_CH6250 | 39.83 | 39.58 | 39.21 | 38.95 | 38.73 | 38.28 | 39.83 | 39.58 | 39.21 | 38.94 | 38.73 | 38.28 | 0.000 | 0.000 | -0.001 | -0.001 | 0.001 | 0.001 |
| H_FSTCK_CH5100 | 45.65 | 45.47 | 45.23 | 45.02 | 44.85 | 44.52 | 45.65 | 45.47 | 45.23 | 45.02 | 44.85 | 44.52 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| H_FSTCK_CH3800_Trib1 | 54.37 | 54.32 | 54.26 | 54.20 | 54.14 | 53.97 | 54.37 | 54.32 | 54.26 | 54.20 | 54.14 | 53.97 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| H_FSTCK_CH3800_Trib2 | 53.51 | 53.43 | 53.30 | 53.21 | 53.14 | 53.01 | 53.51 | 53.43 | 53.30 | 53.21 | 53.14 | 53.01 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| H_FSTCK_CH3350 | 54.54 | 54.36 | 54.10 | 53.90 | 53.77 | 53.48 | 54.54 | 54.36 | 54.10 | 53.90 | 53.77 | 53.48 | 0.000 | 0.000 | -0.001 | 0.000 | 0.000 | 0.000 |
| H_FSTCK_CH3200 | 55.67 | 55.50 | 55.27 | 55.09 | 54.94 | 54.64 | 55.67 | 55.50 | 55.27 | 55.09 | 54.94 | 54.64 | 0.000 | 0.000 | -0.001 | 0.000 | 0.000 | 0.000 |
| H_FSTCK_CH2800 | 57.77 | 57.59 | 57.33 | 57.12 | 56.95 | 56.60 | 57.77 | 57.59 | 57.33 | 57.12 | 56.95 | 56.60 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| H_FSTCK_CH2000 | 61.22 | 61.07 | 60.88 | 60.70 | 60.57 | 60.30 | 61.22 | 61.07 | 60.88 | 60.70 | 60.57 | 60.30 | 0.000 | 0.001 | -0.001 | 0.000 | 0.000 | 0.000 |
| H_FSTCH_CH10650_TEVRD_US | 22.18 | 21.93 | 21.57 | 21.23 | 20.95 | 20.38 | 22.18 | 21.93 | 21.57 | 21.23 | 20.95 | 20.38 | -0.004 | -0.001 | -0.003 | 0.001 | 0.000 | 0.000 |

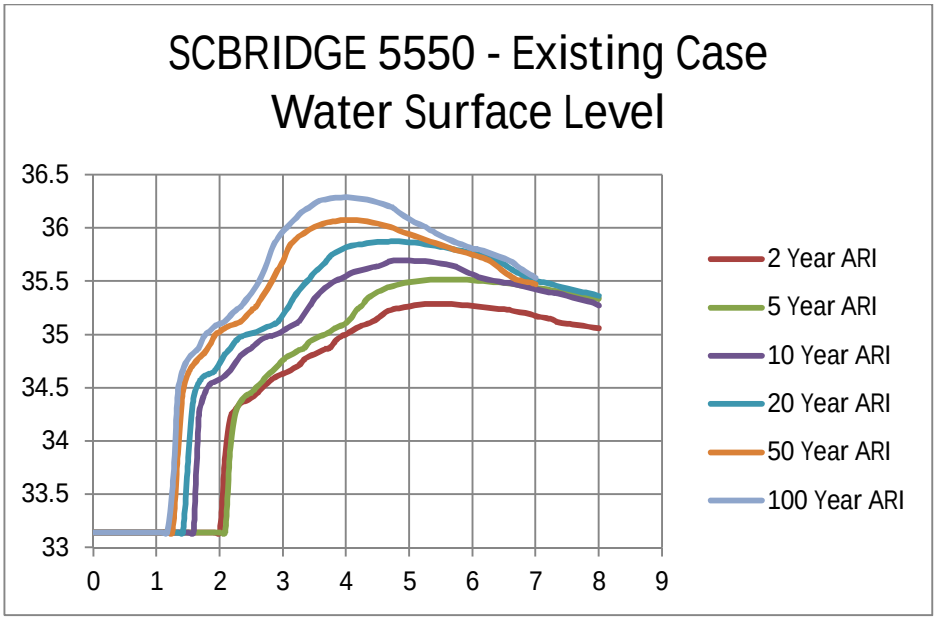
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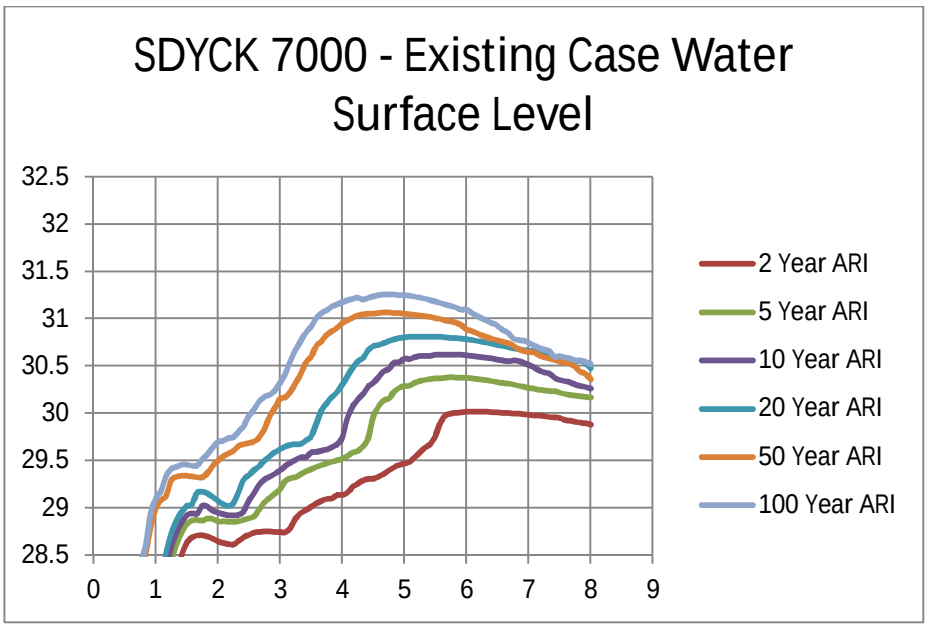
# APPENDIX

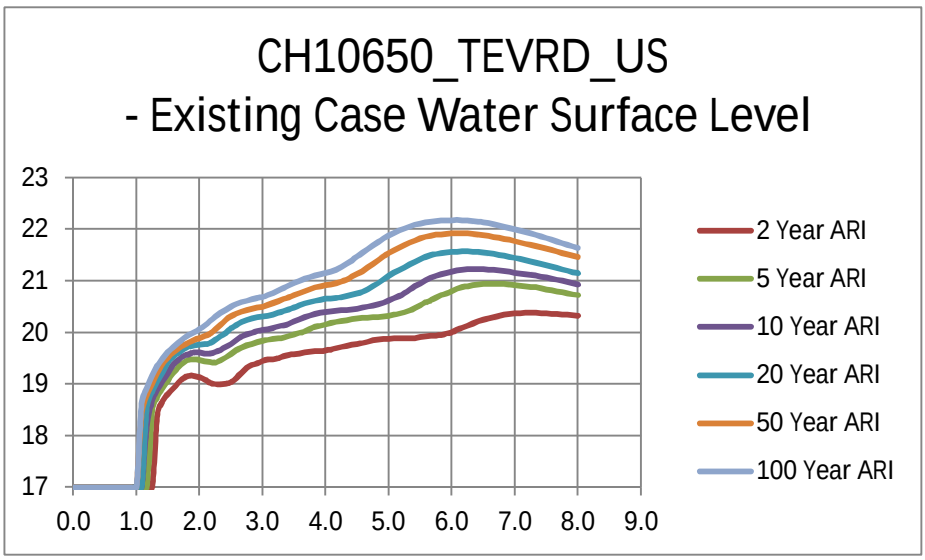
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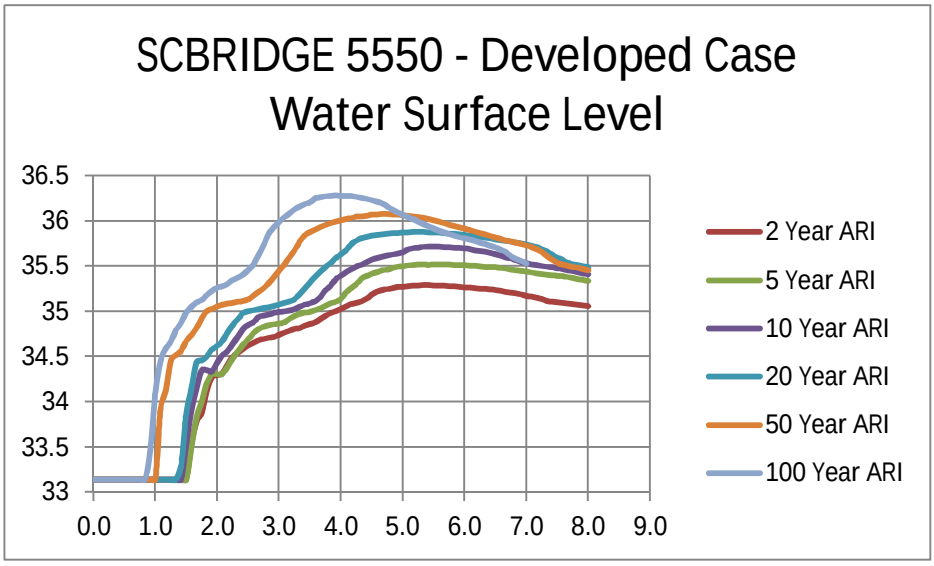
## Pre & Post Development Hydrographs

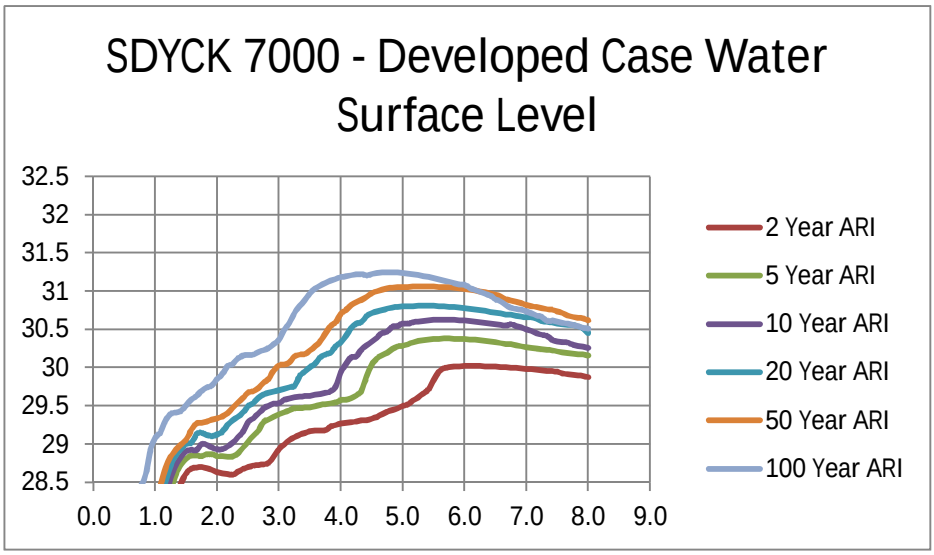
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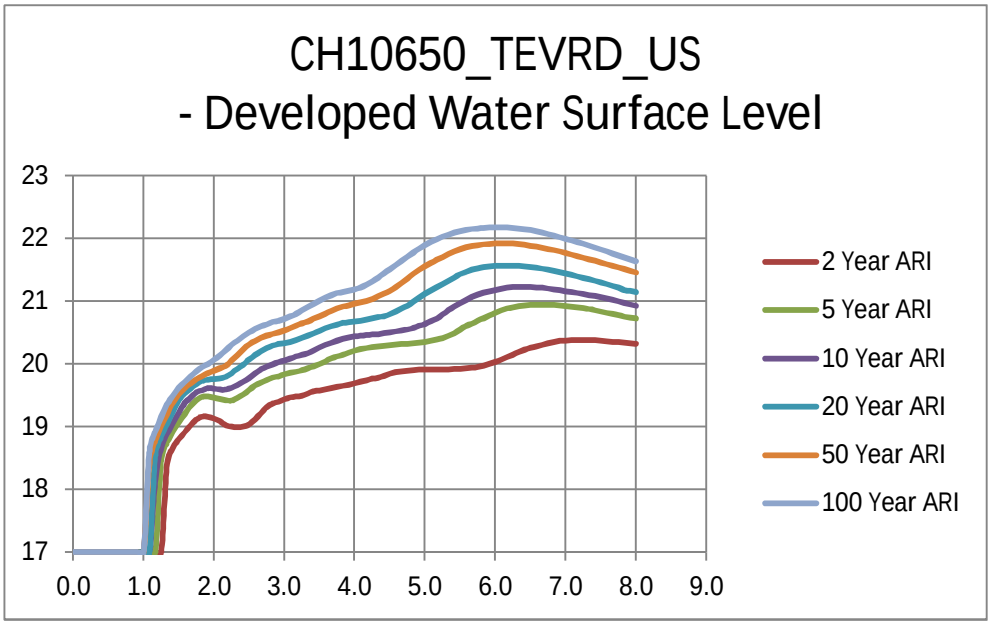

SCBRIDGE 5550 - Existing Case Water Surface Level
36.5
36
35.5
35
34.5
34
33.5
33
0 1 2 3 4 5 6 7 8 9
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI


SDYCK 7000 - Existing Case Water Surface Level
32.5
32
31.5
31
30.5
30
29.5
29
28.5
0 1 2 3 4 5 6 7 8 9
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI


CH10650_TEVRD_US - Existing Case Water Surface Level
23
22
21
20
19
18
17
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI


SCBRIDGE 5550 - Developed Case Water Surface Level
36.5
36
35.5
35
34.5
34
33.5
33
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI


SDYCK 7000 - Developed Case Water Surface Level
32.5
32
31.5
31
30.5
30
29.5
29
28.5
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI


CH10650_TEVRD_US
- Developed Water Surface Level
23
22
21
20
19
18
17
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI