SMEC INTERNAL REF. 30034151

Vulnerability and Tolerability Report

EPW00390 – Vulnerability and Tolerability Report (30034151-RPT-5.1-002) – Revision 0

Client Reference No. EPW00390
Prepared for: Department of Housing, Local Government, Planning and Public Works
23 May 2024

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Document Control

Document Type	Vulnerability and Tolerability Report
Project Title	EPW00390 – Vulnerability and Tolerability Report (30034151-RPT-5.1-002) – Revision 0
Project Number	30034151
File Location	X:\Projects\300341\30034151\100 Prelim Design\Water Resources\Reports\\Vulnerability and Tolerability\RevB\EPW00390 – Vulnerability and Tolerability Report (30034151-RPT-5.1-002) – Revision B
Revision Number	0

Revision History

Revision No.	Date	Prepared By	Reviewed By	Approved for Issue By
A	03 May 2024	Evan O'Brien Jonah Chorley	Rob Tredger	Matt Box
B	17/08/2024	Evan O'Brien Jonah Chorley	Rob Tredger	Matt Box
0	23/05/20204	Evan O'Brien Jonah Chorley	Rob Tredger	Matt Box

Issue Register

Distribution List	Date Issued	Number of Copies
Department of Housing, Local Government, Planning and Public Works	23 May 2024	PDF

SMEC Company Details

Approved by	Matt Box
Address	Level 6/480 St Pauls Terrace, Fortitude Valley QLD, 4006
Phone	(07) 3029 6600
Email	Matt.box@smec.com
Website	www.smec.com
Signature	

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Executive Summary

A flood risk vulnerability and tolerability assessment has been carried out following the planning evaluation process described in Schedule 5 of the Queensland Reconstructing Authority (QRA) document "Planning for stronger more resilient floodplains: Part 2 – Measures to support floodplain management in future planning schemes". The document describes a general methodology for completing an assessment of the community's exposure, vulnerability, and tolerability on a per-building basis, assigning scores which are then transformed into an estimation of consequence. The product of consequence and likelihood is then used to determine the level of risk.

The assessment was undertaken for existing conditions (i.e. no levee) and the proposed future condition post-construction of the Bundaberg East Flood Levee. Likelihoods ranging from 1 in 2 AEP to 1 in 100 AEP were tested in order to capture the spectrum of benefits and impacts across this range of probabilities. The results are provided in Table 1 below. This table summarises the number of buildings subject to acceptable, tolerable and intolerable flood risk for existing and post-development conditions. A supporting set of maps is provided in Appendix A.

Table 1: Number of Buildings Subject to Acceptable, Tolerable and Intolerable Risk

Risk Category	Existing Conditions	Post-Levee Construction	Change
Broadly Acceptable	2,487	4,052	**+1,565**
Tolerable, subject to ALARP	396	-	**-396**
Generally Intolerable	1,292	123	**-1,169**

In general, results of the assessment found that in terms of the number of buildings affected:

- Benefits greatly outweighed impacts across all flood events considered.
- The largest flood event (1 in 100 AEP) benefitted the most structures.
- The risk level of 1,169 buildings was predicted to decrease from "Generally Intolerable" to one of either "Tolerable subject to ALARP" or "Broadly Acceptable", and a further 396 buildings are predicted to decrease from "Tolerable subject to ALARP" to "Broadly Acceptable".
- The risk level of zero buildings was predicted to increase from "Broadly Acceptable" to one of either "Tolerable Subject to ALARP" or "Generally Intolerable" i.e. behind the levee, no buildings are worse off.
- The risk level of 123 buildings are predicted to stay "Generally Intolerable", these are the buildings at about 5.5 mAHD or lower that are subject to internal flood risk due to coincident local catchment runoff. This could be reduced by increasing the pump capacity (subject to cost-benefit analysis).

The outcomes are broadly as expected, and arise due to the facts that:

- The levee does not create significant increases in peak water levels, either in proximity to it, or further afield at North Bundaberg.
- The joint probability of coincident rainfall and flooding on the local catchment in conjunction with a flood greater than 4 metres in the Burnett River is low. Pumps would be operated on Saltwater and Distillery creeks to remove flood water from the local catchment area whilst the gate structures are closed to prevent flooding from the river. Therefore, the flood risk presented to properties that are protected by the levee from coincident flooding on the local catchments that exceeds the pump capacity during the periods that the flood gates are closed is acceptable.
- Sizing of the pump station and supporting infrastructure capacity to manage flood risk will be considered further during detailed design.

1. Introduction

1.1 Overview

SMEC, contracted by the Department of Housing, Local Government, Planning, and Public Works (DHLGPPW) as the Principal Consultant for the design of the Bundaberg East Flood Levee (referred to as "the Project"), has conducted an assessment of vulnerability and tolerability for the Project with consideration for the Burnett River Floodplain and local catchment area. This assessment is intended to provide support for the Ministerial Infrastructure Designation submission. The report evaluates current conditions, anticipated changes following the construction of the Bundaberg Levee, and examines the impacts of the levee on the local community

1.2 Location and Context

The regional Queensland city of Bundaberg is located about 300 km north of Brisbane on the Burnett River. It is the seat of Bundaberg Regional Council, has a population of about 100,000 people, and is the primary service centre for the predominantly agricultural economic activities of the area. Local industries of note include the production of tropical fruit, sugar refining, rum distillation, and tourism.

1.3 Burnett River Flooding

The Burnett River catchment spans an area of some 32,000 km^2 in the Wide-Bay Burnett region of Central Queensland. Spanning approximately 300 km from north to south and about 200 km from east to west at its widest points, the basin is generally considered to be comprised of 5 major sub-catchment areas, namely:

- Upper Burnett. The most northerly portion of the basin, which includes the Nogo River, Three Moon Creek, and the headwaters of the Burnett River.
- Auburn. To the west of Mundubbera, incorporating the Auburn River, Johnson Creek, and Cadarga Creek.
- Boyne. Rising in the Bunya Mountains to the south of Kingaroy, the Boyne and Stuart Rivers flow in a northerly direction to a confluence with the Burnett River near Mundubbera.
- Barker and Barambah Creeks. To the east of the Boyne sub-catchment, also flowing in a generally northerly direction to a confluence with the Burnett River near Gayndah.
- Lower Burnett. The Burnett River downstream of Mundubbera (i.e. below the confluence of the aforementioned tributaries)

Annual rainfall totals exhibit some variability across the catchment. The majority of the catchment inland from the coastal range receives an average of around 800 mm of precipitation annually, whilst the eastern coastal slope is significantly wetter at around 1,200 mm annually. Orographic effects in the Upper Burnett – around the Burnett, Dawes, and Hogback ranges – can be pronounced, leading to higher daily rainfall totals when compared to lower elevations.

The catchment size and shape are such that heavy rainfall in any one of the major sub-catchment areas can be sufficient to cause a flood event at Bundaberg. Flooding is relatively infrequent, and typically requires the sustained rainfall associated with tropical low-pressure systems. For example, the 2013 flood of record at Bundaberg was caused by ex-tropical cyclone Oswald travelling from north to south across the eastern portion of the catchment. Analysis of the rainfall preceding other major floods generally reveals a similar meteorological mechanism and storm track.

Flooding at Bundaberg occurs with several days advance warning, as the development of the flood and the subsequent flood peak is first observed further upstream at the towns of Mundubbera and Gayndah. By the time a large flood reaches Paradise Dam, all the major tributaries have joined the main stream and the flood behaviour downstream of the spillway can usually be predicted with good accuracy. The last reliable streamflow gauge is located at Walla, adjacent the Bruce Highway crossing of the Burnett River and about 38 km downstream of Paradise Dam. From Walla, the average travel time of a large flood peak to Bundaberg is about 15 hours. The Bureau of Meteorology operates a flood warning system in the catchment with the objective of providing a warning lead time of 12 hours for floods greater than 5.5 m (Bureau of Meteorology, 2022). Since settlement, 48 flood events have been recorded at Bundaberg. Of these, 15 (31 %) did not reach the minor flood level of 3.5 m. 19 events (40 %) were classed as minor, peaking below

5.5 m. A further 6 events (12 %) were classified as moderate, peaking below 7 m, and 8 floods (17 %) exceeded the major flood level of 7 m at the Targo Street gauge.

Flooding of the CBD and East Bundaberg occurs via backwater inundation on Saltwater and Distillery Creeks. Inundation of the lowest lying structures (mostly non-habitable) of the CBD fringe and East Bundaberg first occurs at just above 4 m as measured at the Targo Street gauge. Multiple residential dwellings become inundated once flooding exceeds the moderate flood level of 5.5 m. The other notable flood prone area is North Bundaberg, which experiences widespread inundation upon the river breaking its banks; this occurs for when river levels reach about 8 m at the gauge.

1.4 Bundaberg East Flood Levee

The proposed levee alignment encloses the flood prone areas of Saltwater Creek and Distillery Creek, which act predominantly as backwater storages during river flood events. The levee is proposed to run from the CBD riverfront, near the intersection of Quay Street and Toomburra Streets, to the Millaquin Sugar Mill. Two sections of levee are proposed, separated by high ground near the junction of Cran Street and Scotland Street. The proposed levee alignment is shown in plan view in Figure 1.

The morphology of the Burnett River channel and floodplain means that peak flood levels do not vary greatly along the alignment. A uniform crest level has thus been proposed, at 9.5 m AHD. This elevation is equivalent to the 1 in 100 AEP design flood event water surface elevation (~9.2 m AHD) plus a freeboard of 0.3 m, coincidentally setting the levee crest height just above the 2013 flood of record (when assessed at Saltwater Creek).

Figure 1: Proposed Levee Alignment

1.5 Scope of Works

This Vulnerability and Tolerability Assessment Report has been undertaken as part of the Preliminary Design (PD) Phase for the Bundaberg East Levee, to support the Ministerial Infrastructure Designation (MID) planning approvals pathway.

The scope of works considered in this document is as follows:

- Using the relevant guidelines, establish the vulnerability and tolerability of the East Bundaberg and CBD communities under existing conditions.
- Re-assess the vulnerability and tolerability post construction of the Bundaberg East Levee.
- Analyse the effects of the levee on the community risk profile.

It should be noted that whilst the purpose of the levee is to mitigate riverine flooding from the Burnett River only, consideration is also given to the likelihood and impact of local rainfall occurring in the internal Saltwater Creek catchment, via implantation of coincident flood hydrographs to the with-levee flood model.

Communities in areas that are unprotected by the levee have been excluded from this analysis for the simple reason that the levee does not create significant impacts in terms of any of the criteria used in this assessment.

1.6 Assumptions and Exclusions

This Vulnerability and Tolerability Assessment Report has been undertaken considering the following assumptions and exclusions:

- This document is based on the early Bundaberg Levee Preliminary proposed designs as of 17 May 2024. It is noted that this design is a work in progress and will be subject to change during later design milestones.
- The document relies on floor-level data provided by the Bundaberg Regional Council. Where floor level data has not been provided, levels have been interpolated from available LiDAR.
- The Burnett River HEC-RAS model, employed for evaluating existing flood risk, is established; however, the Saltwater Creek HEC-RAS model, utilized for post-development flood risk assessment, along with the coinciding flood analysis, is recently created for this project and is currently undergoing further peer review.

2. Assessment Criteria

2.1 Definitions

Definitions used in the assessment process are taken from the Queensland Reconstruction Authority (QRA) document *“Planning for stronger, more resilient floodplains: Part 2 – Measures to support floodplain management in future planning schemes”* (QRA, 2012). A brief summary of the elements used in the assessment is provided below.

2.1.1 Flood Risk

The commonly accepted definition of risk is employed in this analysis, being the product of likelihood and consequence, per Figure 2.

Figure 2: Flood Risk Equation (from QRA, 2012)

Once a Consequence Score has been calculated (per Section 2.1.3) for each Likelihood, the acceptability of the Risk is given by the flood risk matrix, shown below:

	Consequence Score										
Likelihood	0	1	2	3	4	5	6	7	8	9	10
10%	0	10	20	30	40	50	60	70	80	90	100
5%	0	5	10	15	20	25	30	35	40	45	50
2.5%	0	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25
2%	0	2	4	6	8	10	12	14	16	18	20
1%	0	1	2	3	4	5	6	7	8	9	10
0.5%	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
0.2%	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0.1%	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1

Figure 3: Flood Risk Matrix, from (QRA,2012)

The objectives of this analysis are to demonstrate that construction of the levee:

- Moves the majority of the “Generally Intolerable” risks into the “Broadly Acceptable” region, thus demonstrating a net risk reduction when compared to the existing condition.
- Does not cause an undue increase in risks being shifted into the “Generally Intolerable” region from one of the other two regions.

2.1.2 Likelihood

Generally speaking, likelihood can be understood as the chance of a specific event taking place within a given timeframe. As it relates to flooding, likelihood is expressed in terms of an Annual Exceedance Probability (AEP), whereby for example, the 1 in 100 AEP design flood is defined as having a 1 in 100 (1 %) chance of being met or exceeded in any given year.

The first several low-lying properties in East Bundaberg and the CBD are impacted when the flood height at the Targo Street gauge reaches 4 m, corresponding approximately to a 1 in 2 AEP. The levee is designed to protect against the 1 in 100 AEP level, plus a freeboard allowance of 0.3 m, giving a crest elevation of 9.5 m AHD. The 1 in 200 AEP peak flood level is greater than the levee crest level, meaning that were such a flood to occur no benefit would be realised by having the levee in place. Flood gates would be opened, and the ultimate impacts of the flood would be virtually identical to the existing condition. As such, flood likelihoods from 1 in 2 AEP to 1 in 100 AEP, inclusive, were selected for this assessment as it is across this range of probabilities that benefits can be demonstrated by means of the analysis.

2.1.3 Consequence of Flooding

Quantifying consequence is taken to involve an evaluation of the three contributing factors of exposure, vulnerability, and tolerability, as illustrated in Figure 4 below.

Figure 4: Elements of Consequence (from QRA, 2012)

The components of exposure and vulnerability increase consequences of flooding but can be mitigated by tolerability. For each flood event under consideration, the analysis is carried out on a building-by-building basis, with scores of between 0 and 5 allocated to each component, having regard to the particulars relating to land use, inundated depth, and streamflow velocity. A consequence score is determined by the summation of each component, and comparison made between the existing condition (i.e. no levee) and the proposed condition (i.e. post-levee construction) to gain an overall understanding of how the proposed levee changes the consequences of flooding to affected properties.

2.1.4 Exposure

Exposure is defined as the potential for a flood hazard to create flood risk. A two-step approach is used, in which exposure is assessed first based on hazard severity, and then on built form and associated safety, with the largest of the two values at each assessment point taken to be the governing score. Assessment is carried out in accordance with Table 2. Hazard Severity numbers were derived from the flood model results and calculated following the flood hazard classification of Australian Rainfall and Runoff (Figure 5).

Table 2: Assessment of Hazard (from QRA, 2012)

Hazard Severity	Built Form & Associated Safety	Score
H1 – Generally safe for people, vehicles, and buildings	Landscape	0
H2 – Unsafe for small vehicles	Open space and recreation / rural	1
H3 – Unsafe for vehicles, children, and the elderly	Industrial	2
H4 – Unsafe for people and vehicles	Commercial	3
H5 – As per H4, plus buildings vulnerable to structural damage	Infrastructure & utilities / rural residential	4
H6 – As per H5, plus all type of buildings vulnerable to failure	Residential / community & cultural	5

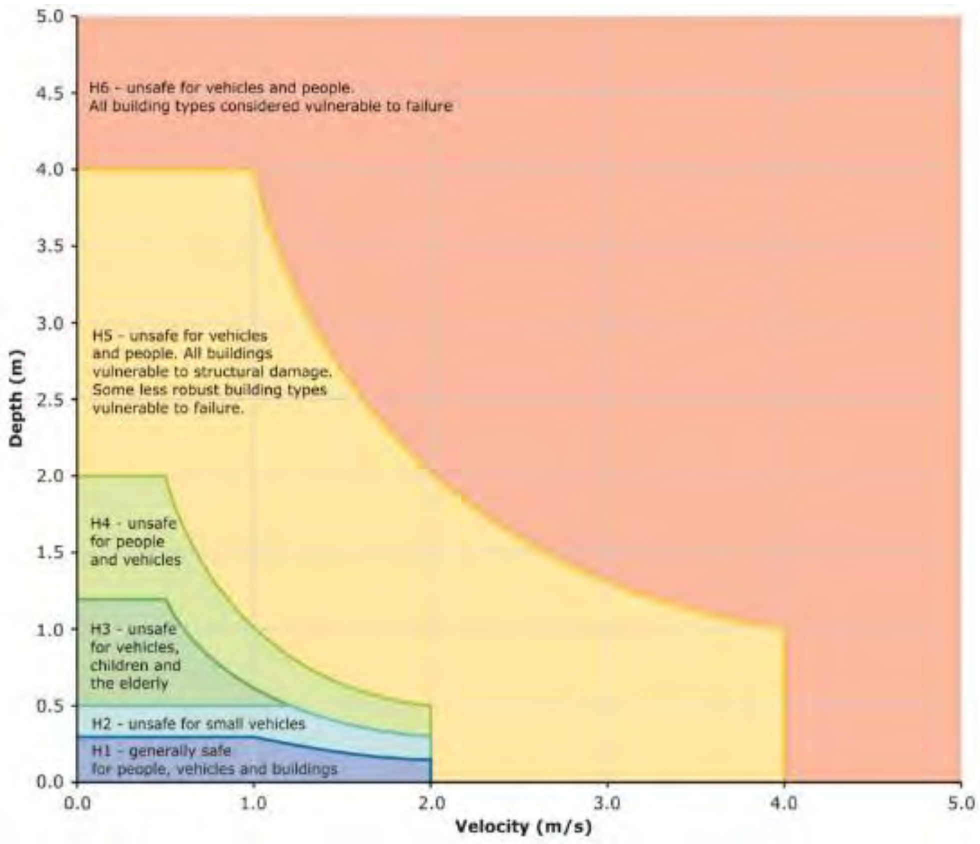


Figure 5: Flood Hazard Classification (from ARR, 2019)

2.1.5 Vulnerability

Vulnerability speaks to the ability of the flood affected community to plan for, cope with, and recover after flood events, and is affected by such characteristics as the land use type, built form, and flood warning time available to that community. These characteristics are assessed using the criteria of Table 3. Each of the three columns is assessed each building and for each flood, with the largest value taken to be the governing score. In the case of flood warning time, no variation with location or flood AEP has been considered, as it is well established that the time taken for a large flood to travel to Bundaberg from Walla (the next gauge upstream) is in the order of 15 hours, giving a uniform score of 3 for this variable. This constitutes the minimum available warning time; in reality the various monitoring points at Paradise Dam and further upstream serve to increase the effective warning time available.

Table 3: Assessment of Vulnerability (from QRA, 2012)

Vulnerable Land Use	Built Form and Associated Safety	Flood Warning Time	Score
Not affected by flood hazard	Not affected by flood hazard	> 3 days	0
Commercial, industrial, rural, and residential without vulnerable persons	At grade – industrial	49 to 72 hours	1
Hazardous materials / warehousing	Elevated above selected flood	25 to 48 hours	2
Community & cultural with vulnerable property, or minor infrastructure	At grade – commercial	13 to 24 hours	3
Community & cultural with vulnerable persons, or residential with vulnerable persons	At grade – community	7 to 12 hours	4
Evacuation centres / airports / other critical infrastructure	Not elevated above selected flood - residential		5

2.1.6 Tolerability

Flood tolerability relates to the attitudes and level of resilience within a community, which can reduce the impacts of flood exposure when an event occurs. This can include both qualitative and quantitative metrics, including personal attitudes to and awareness of flood events, levels of insurance, prevalence of use of flood emergency plans, and the extent to which people assist each other in times of flood. With the exception of the level of protection, which is defined by AEP as calculated from the flood model, the remaining measures of tolerability are highly subjective. In total, (QRA, 2012) lists 6 measures that would ideally be assessed at each lot and for each flood, per Table 4 and Table 5.

Table 4: Assessment of Tolerability (1 of 2) (from QRA, 2012)

Community Awareness / Understanding	Community Perception of Hazard	Community Preparedness	Ability of Critical Infrastructure to Remain Operational During/After Flood Event	Score
Unaware	Intolerant and not resilient	No individual preparedness, business continuity & social networks	Not able to remain operational	0
Partially aware	Fearful and generally not resilient	Limited individual preparedness, business continuity & social networks	N/A	1
Moderately aware	Cautious and moderately resilient	Acceptable individual preparedness, business continuity & social networks	Reduced but acceptable operations	2
Generally aware	Generally tolerant and resilient	Strong individual preparedness, business continuity & social networks	N/A	3
Very aware	Tolerant and resilient	Very strong individual preparedness, business continuity & social networks	Able to remain fully operational	4
No persons or property affected, or emergency services / evacuation procedures and structural controls unnecessary				5

Table 5: Assessment of Tolerability (2 of 2) (from QRA, 2012)

Emergency Management Procedures	Level of Protection (QRA 2012)[1]	Level of Protection (AECOM 2019)[2]	Score
For residential/critical infrastructure: **No** emergency services access, or for non-residential: **No** evacuation procedures in place	None	Inundated, for the property and AEP under consideration	0
As above, replacing “No” with “**Limited”**	less than 1 in 50 AEP	N/A	1
As above, replacing “Limited” with “**Acceptable”**	1 in 50 AEP to 1 in 100 AEP	N/A	2
As above, replacing “Limited” with “**Strong”**	1 in 100 AEP	N/A	3
As above, replacing “Limited” with “**Very Strong”**	more than 1 in 100 AEP	N/A	4
No persons or property affected, or emergency services / evacuation procedures and structural controls unnecessary		Not Inundated, for the property and AEP under consideration	5

[1] Not used in this assessment.

[2] Used in this assessment.

The items listed in Table 4 have not been included in this assessment, as the ability to make accurate judgements would require lot-scale demographic and social survey data that are not available at the time of writing. For the time being, the tolerability assessment has been scored using the categories listed in Table 5 only. However, this simplification is not thought to unduly degrade the quality of the assessment, because for tolerability, it is the *minimum score* that is taken to be the governing score for the location being assessed.

Following the 2013 floods, Bundaberg Regional Council has spent significant effort in developing emergency management procedures, including, but not limited to, a public-facing flood awareness dashboard, accessible via the internet. It would seem reasonable therefore to apply a uniform category of “Acceptable” (Score = 2) to the criterion of Emergency Management Procedures for the existing condition, and a category of “No persons or property affected” (Score = 5) for the post-levee construction scenario, for those properties located on the protected side of the levee, except in the case where coincident interior flooding is shown to degrade the level of protection. Any such properties will be handled on a lot by lot basis.

Turning to the Level of Protection criterion, it is difficult to reconcile the descriptions provided in (QRA, 2012) against the flood model results on a per-building and per-AEP basis, as is done when assessing Exposure and Vulnerability. For example, the level of protection called “less than 1 in 50 AEP” would also presumably have to include the protection level of “None”. Meanwhile, “1 in 100 AEP” is an *exact* level, whereas the others represent ranges. Therefore, for the purposes of harmonising the tolerability assessment on a per-lot and per-AEP basis, the methodology of (AECOM, 2019) has been adopted. A binary approach is utilised. For a particular flood event, a property that is inundated scores zero for tolerability, whilst a property that is not inundated is given a score of five.

3. Vulnerability and Tolerability Assessment

3.1 Input Data

3.1.1 Building Database

Bundaberg Regional Council (BRC) provided a database of building footprints, in GIS format for use in this assessment. In addition to the spatial data, the attribute table contained the following fields of relevance:

- “TAG” – Building use categorised into: Residential, Industrial, Commercial, Church, School, Unknown.
- “FLOOR_HEIGH” – surveyed floor heights, available for slightly less than half of the features in the GIS layer.

As received from BRC, the “TAG” field contained a significant number of entries labelled as Unknown. Using the available aerial imagery, street maps, Google Street View, and knowledge of the town, all such entries located below an elevation of 10 m AHD were re-categorised. Finally, the centroid of each building footprint was calculated, to enable point-sampling of hydraulic model results, as shown in Figure 6 below.

Figure 6: Building Footprints, Centroids and Classifications

Where surveyed floor heights were not available, the natural surface elevation was taken to be the floor height, sampled from the LiDAR at the building centroid point. This represents a worst-case scenario because, in reality, the finished floor level of most houses will be at-least 100 mm above the LiDAR level if they are slab on ground construction, or higher if stumped.

3.1.2 Hydraulic Model Results

Peak flood hazard and depths for the existing condition were sourced from the Burnett River HEC-RAS model, development of which is described in detail in the document “Burnett River Surface Water Modelling Technical Report, CDM Smith 2019”, this being Appendix D to “Bundaberg East Levee – Concept Engineering Report, CDM Smith 2019”. The model was updated to the latest software version for this study, and it was confirmed that the previous calibration held. Effects of levee construction were again validated as being minor in nature; with water level increasing by no more than 0.03 m on properties located on the unprotected side at Quay Street East, and increasing by no more than 0.01 m across the main river channel in North Bundaberg. For the purposes of statutory approvals, water level increases occasioned by the levee are less than the +0.05 m threshold, and velocities increases are less than the +0.2 m/s threshold, above which impacts are classified as “significant” (Department of Regional Development, Manufacturing and Water, 2022). For further detail, refer to the Surface Water Technical Report, Section 4.3.3.

Peak flood hazard and depths for the post-levee condition were sourced from a new HEC-RAS model of Saltwater Creek, recently developed for the Bundaberg Levee Detailed Design Project. This model utilises riverine boundary conditions from the Burnett River model, but is focussed on quantifying the risk of interior flooding when the levee flood gates are closed and local rainfall occurs in the Saltwater Creek catchment. The combinations of river flood levels and interior rainfall patterns were developed following the joint probability method described in Australian Rainfall and Runoff (2019). Outcomes of this study are described in detail in the report “Bundaberg East Flood Levee Detailed Design – Surface Water Technical Report” (SMEC, 2024). As a brief overview, the risk of interior flooding is expected to be low, and to the extent that internal runoff does occur during a river flood, interior levels are mitigated by the large storage volume available in Kendall Flat/Baldwin Swamp, and by the levee pump station.

It should be noted that whilst the Burnett River HEC-RAS model (used to assess existing flood risk) is mature, the Saltwater Creek HEC-RAS model (used to assess post-development flood risk), and the underlying coincident flood analysis, are new developments and as such are likely to be revised multiple times throughout the detailed design. The pump size is also subject to change and may be iteratively determined based on the outcomes of this report, or similar cost-benefit analysis in the context of flood risk. Therefore, the Vulnerability and Tolerability results presented in the following section should not be taken as final, this will remain a live document until the detailed design is finalised.

3.2 Results

The results of the vulnerability and tolerability assessment are provided in the following sections. For each contributing factor of consequence (exposure, vulnerability and tolerability), there is a dedicated sub-section with three (3) tables to summarise the existing conditions, post-levee conditions and change, respectively. The resultant consequence ratings and associated risk levels (once likelihood is accounted for) are summarised in the same way.

3.2.1 Exposure

Table 6: Exposure Assessment Results – Number of Buildings for Existing Conditions

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	1 in 5 AEP	1 in 2 AEP
0	2,617	3,147	3,738	4,049	4,139	4,171
1	177	125	74	20	11	1
2	274	234	99	41	9	3
3	298	206	96	28	10	-
4	204	109	46	23	4	-
5	605	354	122	14	2	-

Table 7: Exposure Assessment Results – Number of Buildings Post-Levee Construction

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	1 in 5 AEP	1 in 2 AEP
0	4,088	4,087	4,088	4,101	4,144	4,170
1	20	20	20	18	8	1
2	21	22	21	16	10	4
3	20	20	20	18	7	-
4	18	18	18	15	4	-
5	8	8	8	7	2	-

Table 8: Change in Exposure due to Levee Construction (Number of Buildings)

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	1 in 5 AEP	1 in 2 AEP
0	1471	940	350	52	5	-1
1	-157	-105	-54	-2	-3	0
2	-253	-212	-78	-25	1	1
3	-278	-186	-76	-10	-3	-
4	-186	-91	-28	-8	-	-
5	-597	-346	-114	-7	-	-

3.2.2 Vulnerability

Table 9: Vulnerability Assessment Results – Number of Buildings Existing Conditions

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	1 in 5 AEP	1 in 2 AEP
0	-	-	-	-	-	-
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	2,836	3,276	3,794	4,036	4,107	4,135
4	36	36	36	36	36	36
5	1,303	863	345	103	32	4

Table 10: Vulnerability Assessment Results – Number of Buildings Post-Levee Construction

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	1 in 5 AEP	1 in 2 AEP
0	-	-	-	-	-	-
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	4,065	4,064	4,065	4,074	4,112	4,134
4	36	36	36	36	36	36
5	74	75	74	65	27	5

Table 11: Change in Vulnerability due to Levee Construction (Number of Buildings)

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	1 in 5 AEP	1 in 2 AEP
0	-	-	-	-	-	-
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	1229	788	271	38	5	-1
4	-	-	-	-	-	-
5	-1229	-788	-271	-38	-5	1

3.2.3 Tolerability

Table 12: Tolerability Assessment Results – Number of Buildings Existing Conditions

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	1 in 5 AEP	1 in 2 AEP
0	1,898	1,332	602	202	49	6
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	2,277	2,843	3,573	3,973	4,126	4,169

Table 13: Tolerability Assessment Results – Number of Buildings Post-Levee Construction

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	1 in 5 AEP	1 in 2 AEP
0	122	123	122	101	47	7
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	4,053	4,052	4,053	4,074	4,128	4,168

Table 14: Change in Tolerability due to Levee Construction (Number of Buildings)

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	1 in 5 AEP	1 in 2 AEP
0	-1776	-1209	-480	-101	-2	1
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	1776	1209	480	101	2	-1

3.2.4 Consequence

Table 15: Consequence Assessment Results – Number of Buildings Existing Conditions

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	1 in 5 AEP	1 in 2 AEP
0	2,277	2,843	3,573	3,973	4,126	4,169
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	338	299	162	76	13	2
4	2	5	3	-	-	-
5	59	36	24	8	-	-
6	290	215	129	33	15	1
7	276	227	84	35	9	3
8	189	118	41	15	6	-
9	161	88	41	21	4	-
10	583	344	118	14	2	-

Table 16: Consequence Assessment Results – Number of Buildings Post-Levee Construction

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	1 in 5 AEP	1 in 2 AEP
0	4,053	4,052	4,053	4,074	4,128	4,168
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	35	35	35	27	16	2
4	-	-	-	-	-	-
5	4	4	4	2	-	-
6	28	28	28	25	12	1
7	18	19	18	14	10	4
8	12	12	12	11	3	-
9	17	17	17	15	4	-
10	8	8	8	7	2	-

Table 17: Change in Consequence due to Levee Construction (Number of Buildings)

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	1 in 5 AEP	1 in 2 AEP
0	1776	1209	480	101	2	-1
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	-303	-264	-127	-49	3	0
4	-2	-5	-3	0	0	0
5	-55	-32	-20	-6	0	0
6	-262	-187	-101	-8	-3	0
7	-258	-208	-66	-21	1	1
8	-177	-106	-29	-4	-3	0
9	-144	-71	-24	-6	0	0
10	-575	-336	-110	-7	0	0

3.2.5 Risk Level

The final risk levels are summarized for individual design flood events in the following tables (again, for existing conditions, post-levee construction and change due to levee construction, respectively). Although this is a common way of reporting results, the risk level associated with any one pairing of consequence and likelihood does not describe the *absolute* risk i.e. for a given building the risk should either be acceptable, tolerable or intolerable based on all possible flood events. Therefore, an additional column has been added which is based on the maximum risk level across all design flood events i.e. frequent events, although less severe, could produce a higher risk rating and vice versa.

To support the assessment, maps identifying absolute building risk for existing conditions, post-levee construction and change due to levee construction are provided in Appendix A. These should be viewed in conjunction with the below tables to understand where the benefit is being gained.

Table 18: Count of Buildings by Risk Level, Existing Conditions

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	Absolute*
Broadly Acceptable	2,615	2,843	3,573	3,973	2,487
Tolerable, subject to ALARP	627	299	-	-	396
Generally Intolerable	933	1,033	602	202	1,292

Table 19: Count of Buildings by Risk Level, Post-Levee Construction

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	Absolute*
Broadly Acceptable	4,088	4,052	4,053	4,074	4,052
Tolerable, subject to ALARP	50	35	-	-	-
Generally Intolerable	37	88	122	101	123

Table 20: Change in Count of Buildings by Risk Level, due to Levee Construction

Score	1 in 100 AEP	1 in 50 AEP	1 in 20 AEP	1 in 10 AEP	Absolute*
Broadly Acceptable	+1473	+1209	+480	+101	+1565
Tolerable, subject to ALARP	-577	-264	0	0	-396
Generally Intolerable	-896	-945	-480	-101	-1169

*****This is the absolute risk based on the maximum risk level across all design flood events. It is the final rating.

4. Conclusion

A vulnerability and tolerability assessment was carried out, guided by the planning evaluation process described in Schedule 5 of the QRA document “Planning for stronger more resilient floodplains: Part 2 – Measures to support floodplain management in future planning schemes” (2012). The document describes a general methodology for completing an assessment of the community’s exposure, vulnerability, and tolerability on a per-building basis, assigning scores which are then transformed into an estimation of consequence. Consequence and likelihood are then used to determine the level of risk.

The assessment was undertaken for existing conditions (i.e. no levee) and the proposed future condition post-construction of the Bundaberg East Flood Levee. Likelihoods ranging from 1 in 2 AEP to 1 in 100 AEP were tested in order to capture the spectrum of benefits and impacts across this range of probabilities.

In general, results of the assessment found that in terms of the number of buildings affected:

- Benefits greatly outweighed impacts across all flood events considered.
- The largest flood event (1 in 100 AEP) benefitted the most structures.
- The risk level of 1,169 buildings was predicted to decrease from “Generally Intolerable” to one of either “Tolerable subject to ALARP” or “Broadly Acceptable”, and a further 396 buildings are predicted to decrease from “Tolerable subject to ALARP” to “Broadly Acceptable”.
- The risk level of zero buildings was predicted to increase from “Broadly Acceptable” to one of either “Tolerable Subject to ALARP” or “Generally Intolerable” i.e. behind the levee, no buildings are worse off.
- The risk level of 123 buildings are predicted to stay “Generally Intolerable”, these are the buildings at about 5.5 mAHD or lower that are subject to internal flood risk due to coincident local catchment runoff. This could be reduced by increasing the pump capacity (subject to cost-benefit analysis).

The outcomes are broadly as expected, and arise due to the facts that:

- The levee does not create significant increases in peak water levels or velocities, either in proximity to it, or further afield at North Bundaberg. Refer to the Surface Water Technical Report, Section 4.3.3 for detailed discussion of the far-field impacts.
- The joint probability of coincident rainfall and flooding on the local catchment in conjunction with a flood greater than 4 metres in the Burnett River is low. Pumps would be operated on Saltwater and Distillery creeks to remove flood water from the local catchment area whilst the gate structures are closed to prevent flooding from the river. Therefore, the flood risk presented to properties that are protected by the levee from coincident flooding on the local catchments that exceeds the pump capacity during the periods that the flood gates are closed is acceptable.
- Sizing of the pump station and supporting infrastructure capacity to manage flood risk will be considered further during detailed design.

5. References

AECOM (2019), *Appendix* O - *South Rockhampton Flood Levee Vulnerability and Tolerability Report*

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2019, *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia.

CDM Smith (2019), *Bundaberg East Levee – Concept Engineering Report*.

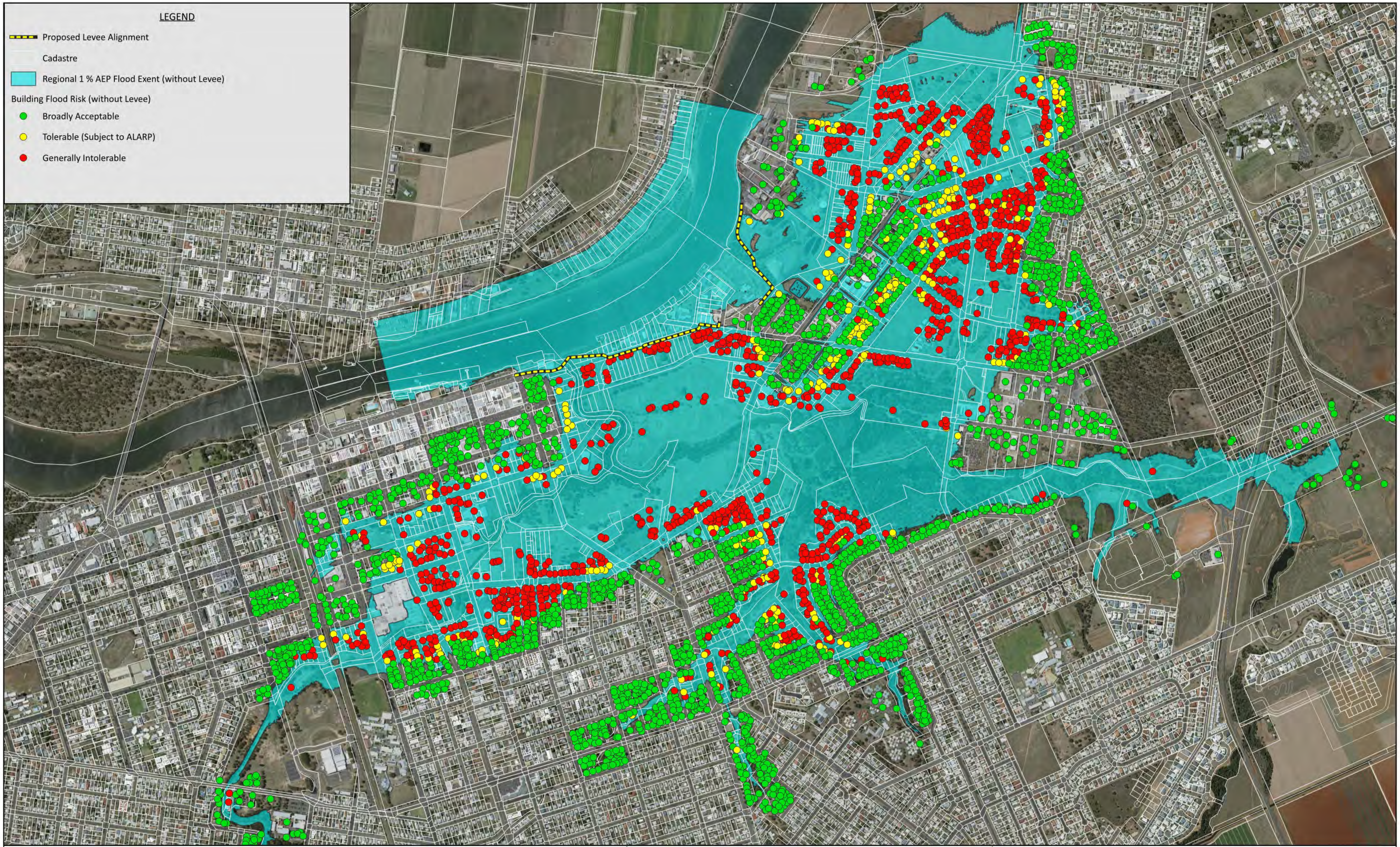
CDM Smith (2019), *Appendix D – Burnett River Surface Water Modelling Technical Report*

SMEC (2024), *Bundaberg East Levee Detailed Design – Surface Water Technical Report*

Queensland Reconstruction Authority (2012), *Planning for stronger more resilient floodplains: Part 2 – Measures to support floodplain management in future planning schemes.* Queensland Government.

Appendix A

Building Flood Risk Assessment Maps



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MAP NO:	30034151-MAP-5.1-001 (1 of 3)

SCALE: 1:15,000

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REVISION:	B	DATE:	15/05/24
STATUS:	DRAFT	SIZE:	A3
AUTHOR:	J. Chorley	SOURCES:	QLD Globe Imagery (c)
CHECKED:	-	CRS:	GDA94 / MGA zone 56

CLIENT:

Queensland Government

CONSULTANT:

SMEC

Member of the Surbana Jurong Group

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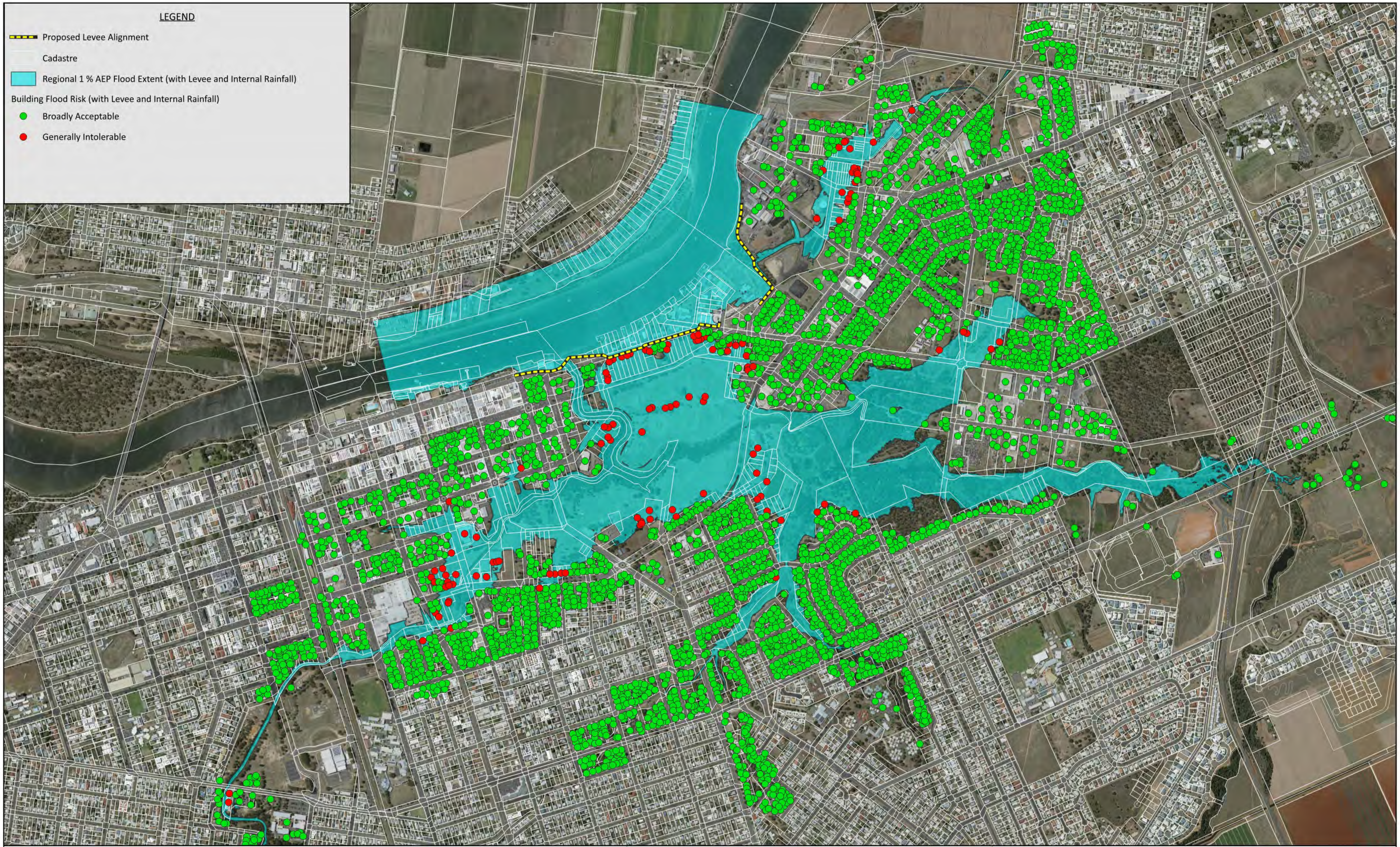

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PROJECT NO:	30034151
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MAP NO:	30034151-MAP-5.1-001 (2 of 3)

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STATUS:	DRAFT	SIZE:	A3
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CHECKED:	-	CRS:	GDA94 / MGA zone 56

CLIENT: Queensland Government

CONSULTANT: SMEC
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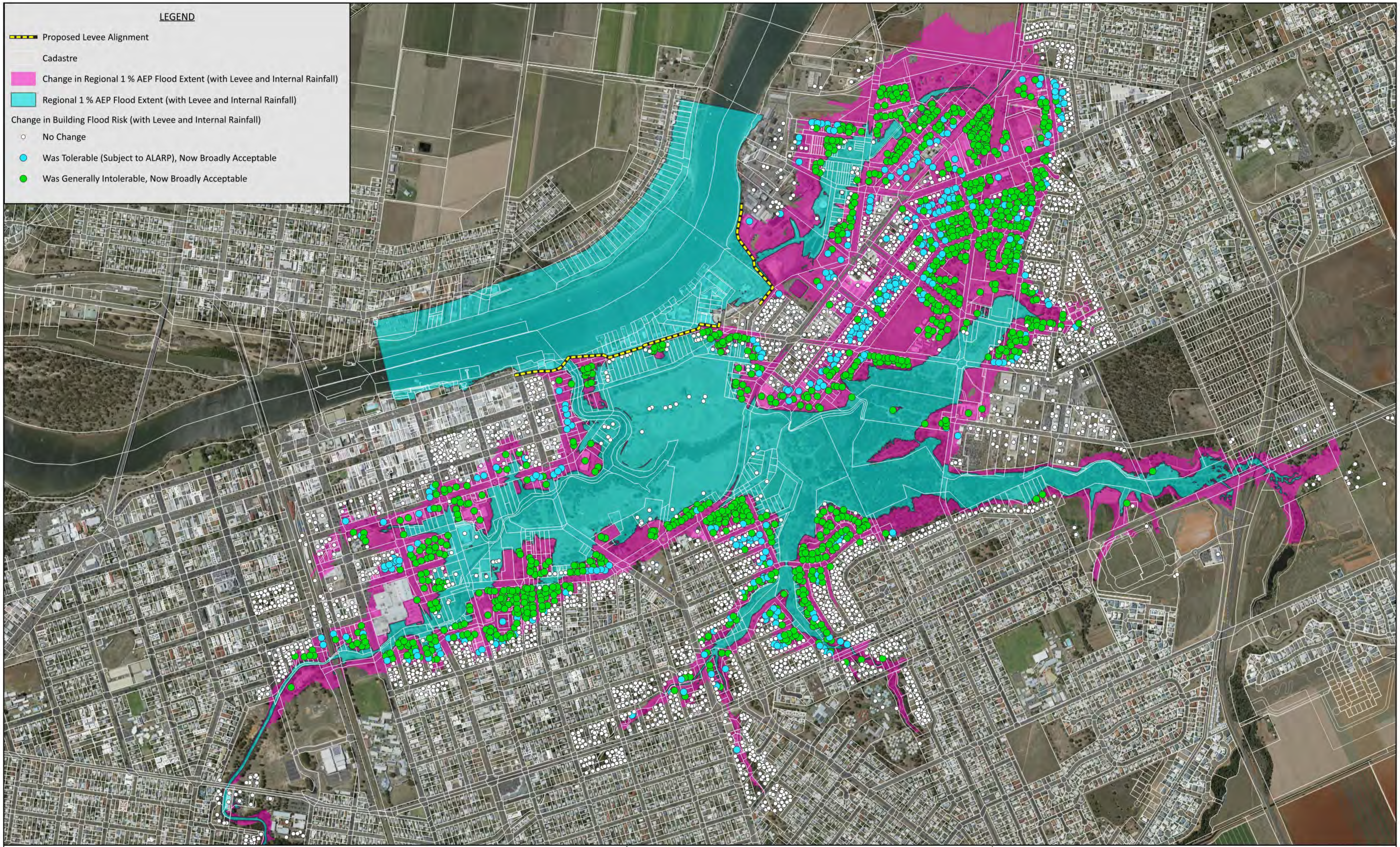

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MAP NO:	30034151-MAP-5.1-001 (3 of 3)		

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REVISION:	B	DATE:	15/05/24
STATUS:	DRAFT	SIZE:	A3
AUTHOR:	J. Chorley	SOURCES:	QLD Globe Imagery (c)
CHECKED:	-	CRS:	GDA94 / MGA zone 56

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Member of the Surbana Jurong Group

SMEC
Meanjin Country, Level 6, 480 St Pauls Tce, Fortitude Valley, QLD, 4006, Australia
PO Box 2211, Fortitude Valley QLD 4006
Phone: 07 3029 6600

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