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MANAGEMENT ASSESSMENT
KINGS FOREST STAGE 1
PROJECT APPLICATION
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NEW SOUTH WALES

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SYNOPSIS This document constitutes a report of the Flooding and Flood Management in support of the Kings Forest Stage 1 Project Application, Kings Forest, New South Wales.

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SUMMARY

Project 28 Pty Ltd commissioned Gilbert & Sutherland Pty Ltd (G&S) to provide a Flooding and Flood Management Assessment in support of the Kings Forest Stage 1 Project Application.

Detailed flood modelling for the site including the proposed future development and climate change scenarios has been carried out. The flood study results indicate that the development site is subject to potential flooding from both local and regional runoff events and is also influenced by potential sea level rise, storm surge and climate change effects.

Based on the studies and investigations carried out to date, we conclude that:

- The majority of the proposed development incorporating the Stage 1 works is above current flooding influence and future climate change affected flooding and no significant adverse off site impacts are predicted.
- Habitable flood levels have been set at a minimum of 0.7m above the upper limit high climate change (0.91m sea level rise plus 30% increase in rainfall intensity) ARI 100 year case (and therefore also above the 10% increase in rainfall climate change level).
- The internal road network can be designed to provide flood-free access up to the design ARI 100 year high climate change flood and can also provide flood free access generally up to the ARI 500 year flood.
- Appropriate and safe emergency evacuation routes can be provided in association with an early warning system to trigger activation of an evacuation plan in the rare event of an actual flood that is likely to exceed the design ARI 100 year flood.
- Flood velocities are low and non-scouring and generally less than 0.5m/s and as such are not likely to pose any significant risks to the public or to private and public infrastructure.

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1 Introduction

1.1 Background

Project 28 Pty Ltd commissioned Gilbert & Sutherland Pty Ltd (G&S) to provide a Flooding and Flood Management Assessment in support of the Kings Forest Stage 1 Project Application.

This report therefore describes flooding and flood management for the proposed Stage 1 Project Application in accordance with:

- The latest Master Plan dated December 2010
- Recent Council decisions in relation to the levels set for minimum habitable floor levels and road levels

- Concept Approval conditions dated 22 December 2010 and;
- The Director General's Environmental Assessment Requirements (DGRs) for Project Application No. 08_0194, dated 23 December 2010.

This report was originally prepared by Principal Hydrologist and Water Resources Engineer Neil Collins, who has since joined the firm BMT WBM. However Mr Collins remains involved with the project and has reviewed the flooding implications of subsequent changes to the proposal.

This assessment is based on existing survey data and preliminary civil design details for the proposed works provided by Mortons Urban Solutions.

2 The existing site

2.1 Location

The Kings Forest Concept Plan covers an area of approximately 870 hectares and is situated immediately northwest of Cudgen Lake and approximately three kilometres south of the township of Kingscliff.

The site location is shown on Drawing No. 10468.1.1.

2.2 Receiving environment

The land ranges in elevation from approximately RL 0m Australian Height Datum (AHD) to RL 55m AHD.

Runoff from this development generally flows in an easterly direction via a number of unnamed ephemeral gullies and SEPP14 wetlands into Cudgen Creek.

Cudgen Creek flows in a northerly direction from Cudgen Lake, which lies to the south-east of the site, to its mouth at Kingscliff, approximately 4.5 km to the north-east of the site.

2.3 Existing development

The site has been selectively cleared. A large portion of the site was used as a pine plantation which has recently been harvested and removed.

There are a number of dwellings and farm sheds on the subject land.

3 The proposed development

The approved Kings Forest Concept Plan proposes the creation of a residential community inclusive of associated educational, social, commercial, sporting and recreational amenities. The development is to be completed in stages.

The Kings Forest Stage 1 Project Application seeks approval for a rural retail development in Precinct 1, residential development in Precinct 5 and bulk earthworks within the balance of the site. A Precinct Plan prepared by MPS Architects is provided in Attachment 2.

The proposed development would include:

- Subdivision to create new lots/land parcels for future development.
- Construction of the entrance road to the site and associated works for the intersection with Tweed Coast Road, as well as a new connecting road to the Tweed Shire Council's former waste tip.
- Subdivision and associated infrastructure works for the first stage of urban development (Precinct 5).
- Bulk earthworks and planting for the future golf course.
- A rural retail development (commercial site) on the developable land east of Tweed Coast Road.
- Bulk earthworks as required in all precincts.

The ultimate proposed development includes the construction and/or installation of the following components:

- site earthworks
- roads / trafficable areas
- stormwater drains
- sewer reticulation mains
- water reticulation mains
- underground electricity distribution cables
- telecommunications cables
- other ancillary services
- construction/building works
- landscaping.

The revised Master Plan by MPS Architects is included in the reference drawings for this report.

Given that the present application is for Stage 1 of the Master Plan, detailed road and allotment layouts have not been completed for the whole of the project, however preliminary bulk earthworks design, site grading and drainage design have been prepared.

4 Assessment of flooding constraints and impacts

The site is subject to flooding from both local catchment runoff and regionally under the influence of Cudgen Creek flooding in combination with regional storm surge effects.

Separate assessments (Flooding Assessment, Kings Forest, Kingscliff, NSW by G&S December 2009 and; Local Hydrological Assessment, Kings Forest, Kingscliff, NSW by G&S December 2009) have been undertaken of both the local and regional flooding to assess the development constraints for the site and the potential impacts of the development on external flooding. These included allowance of a 30% maximum increase in rainfall intensity in addition to 0.91m sea level rise for a High Climate Change scenario and are included as Appendix 1 and 2.

In response to subsequent queries from the Department of Planning and Tweed Shire Council (TSC) decisions in relation to the levels set for minimum habitable floor levels and road levels, further modelling has been undertaken to consider a 10% increase in rainfall intensity and 0.91m sea level rise for the existing case.

It should be noted here that the modelling undertaken to date is based on the approved Concept Plan as detailed in the Preferred Project Report dated August 2009. This plan has been amended for the Stage 1 Project Application to include a minor reconfiguration of the proposed lake, however, it is considered that the new configuration is unlikely to result in significant changes to the modelling results. A statement to this effect has been provided by Neil Collins of BMT WBM and is attached as Appendix 4.

4.1 Assessment of local and regional hydrology

An investigation of local hydrology was undertaken for the purposes of assessing the potential local impacts of the development and to determine design flows to be used as inputs to a separate hydraulic model.

Runoff from the local catchment was modelled using the Watershed Bounded Network Model (WBNM) computer modelling software. This was calibrated to peak design flows estimated using the Rational Method in accordance with the local requirements of Tweed Shire Council. The local catchment plan is shown in Drawing 10468.1.2.

Design peak flow and runoff hydrographs have been derived for a wide range of both local and regional flooding scenarios for design floods from the 5 year ARI to the 100 year ARI flood. These were then used as inputs into a detailed 2D dynamic flood model.

An independent assessment of the regional hydrology has not been undertaken.

4.2 Mitigation of potential development impacts

The hydrologic modelling was used to determine the potential impacts of the development on local runoff as a starting point for the detailed design phase.

The Integrated Water Cycle Management Plan, Stage 1 Project Application, Kings Forest, NSW, (February 2010) details industry best management practices, water sensitive urban design and integrated water management principles to mitigate any potential impacts of the development back to the existing pre-development conditions.

With the implementation of these management principles, the Stage 1 development is expected to have no measurable impact on downstream peak flows and flood levels.

4.3 Assessment of potential climate change impacts

To assess the predicted impacts of future climate change, modifications were made to the Existing Case hydrologic model in accordance with the NSW Climate Change Policy, to include a 10% increase in design rainfall intensity. This was achieved by increasing the magnitude of the intensity data in the IFD table by 10%, and subsequently re-running the WBNM model to generate alternative hydrographs for input into the regional flood model.

The previous assessment, described in the Local Hydrologic Assessment (G&S, November 2009), included as Appendix 2, considered a high climate change scenario with 30% increase in rainfall intensity, this has now been revised down to 10% and results of the revised modelling are presented in Appendix 3, alongside an updated IFD table representing the 10% climate change scenario.

4.4 Assessment of local and regional flooding

Both local and regional flooding have been assessed in detail using the 2D flood modelling software package TUFLOW. For the purpose of this assessment, G&S has utilised the Tweed/Byron Coastal Creeks Flood Study TUFLOW model. (Final report Nov 2009).

The regional hydraulic TUFLOW model was used to assess the existing case flood levels applicable to the whole development site.

Based on the proposed Stage 1 earthworks levels provided by Mortons Urban Solutions, the TUFLOW model topography was then altered and the model was rerun to assess design flood levels applicable to the entire development site.

Drawings numbered 10468.1.3 and 10468.1.4 respectively provide detail on the base topography and proposed development topography used in the sub-model. Drawing 10468.1.5 shows the overall TUFLOW model extent.

The TUFLOW Reporting Point Locations are shown on Drawing 10468.1.6.

The most recent (July 2010) assessment of flooding included the combined effects of regional storm surge and future sea level rise of 0.91m, in accordance with adopted NSW Government policy and a 10% increase in rainfall intensity as agreed with Tweed Shire Council. This assessment is in accordance with the DGRs dated 23 December 2010 and was undertaken to augment the previous modelling in December 2009 which incorporated a High Climate Change scenario including a 30% increase in rainfall intensity in addition to the 0.91m sea level rise. As no change was required to the previous modelling for the ARI 5 year to ARI 100 year design flood events including the probable maximum flood

(PMF), only the December 2009 results for these scenarios are included below.

4.5 Results of flood modelling

The existing pre-development ARI 100 year event peak water levels for the site are shown on Drawing 10468.1.7.

The developed site ARI 100 year event peak water levels are shown on Drawing 10468.1.8.

The ARI 100 year (developed – existing) impacts for the site are shown on Drawing 10468.1.9.

The results of the previous (December 2009) modelling incorporating a range of design flood scenarios from the 5 year ARI flood to the 100 year ARI design flood, including the probable maximum Flood (PMF) which represents the upper boundary of likely flooding for the site, are presented in detail in Appendix 1.

A summary of the design flood levels and potential flood level impacts for the site based on the previous (December 2009) and more recent (July 2010) modelling are presented in Tables 4.1.1 and 4.1.2 at the end of this section.

These results have been used to prepare the preliminary concept design layouts of the subdivision and to facilitate the incorporation of flood proofing measures and disaster management requirements within the development master plan in the event of rare and extreme floods (in excess of the design 100 year ARI flood).

In summary, the analysis described above demonstrates that no adverse impacts on peak flood levels for the presented design storm events are experienced as a result of the proposed development. Some minor increases are observed in the two and five year events over a localised area, however these impacts will be reduced once further detailed design is carried out.

The requirements for flood plain management principles to be incorporated into the development are discussed in Section 5 of this report.

Table 4.1.1 – Assessment of potential flood impacts for major and extreme design floods

Reporting Point	100			50			PMF		100 (Climate Change)		
	Existing (mAHD)	Developed (mAHD)	Impact (m)	Existing (mAHD)	Developed (mAHD)	Impact (m)	Existing (mAHD)	Developed (mAHD)	Existing (30%) (mAHD)	Developed (30%) (mAHD)	Existing (10%) (mAHD)
A	2.173	2.174	0.001	1.705	1.715	0.010	5.291	5.293	2.764	2.766	2.732
B	2.556	2.560	0.004	2.275	2.278	0.003	5.411	5.413	3.118	3.119	2.802
C	2.766	2.765	-0.001	2.572	2.572	0.000	5.608	5.612	3.265	3.264	2.979
D	2.992	2.857	-0.135	2.843	2.669	-0.174	5.649	5.647	3.362	3.308	3.143
E	3.014	2.902	-0.112	2.862	2.743	-0.119	5.662	5.653	3.379	3.325	3.164
F	3.020	2.907	-0.113	2.867	2.747	-0.120	5.665	5.654	3.385	3.327	3.17
G	3.026	2.919	-0.107	2.872	2.759	-0.113	5.666	5.655	3.391	3.333	3.176
H	3.032	2.924	-0.108	2.878	2.764	-0.114	5.667	5.656	3.397	3.336	3.182
I	3.049	2.951	-0.098	2.897	2.794	-0.103	5.668	5.656	3.408	3.348	3.195
J	4.235	4.201	-0.034	4.199	4.136	-0.063	5.668	5.656	4.325	4.374	4.353
K	4.471	4.453	-0.018	4.426	4.412	-0.014	5.668	5.656	4.604	4.576	4.507
L	4.449	4.392	-0.057	4.390	4.324	-0.066	5.668	5.656	4.593	4.536	4.492
M	3.441	3.464	0.023	3.400	3.428	0.028	5.667	5.655	3.539	3.567	3.536
N	3.338	3.352	0.014	3.293	3.318	0.025	5.667	5.655	3.431	3.447	3.443
O	3.040	2.956	-0.084	2.896	2.848	-0.048	5.666	5.655	3.394	3.339	3.183
P	2.864	2.867	0.003	2.669	2.673	0.004	5.670	5.662	3.352	3.352	3.074
Q	2.912	2.918	0.006	2.714	2.720	0.006	5.714	5.701	3.402	3.404	3.124
R	2.924	2.930	0.006	2.725	2.732	0.007	5.728	5.714	3.414	3.416	3.136
S	2.925	2.931	0.006	2.726	2.732	0.006	5.732	5.719	3.416	3.418	3.137

Table 4.1.2 – Assessment of potential flood impacts for minor design floods

Reporting Point	20			10			5		
	Existing (mAHD)	Developed (mAHD)	Impact (m)	Existing (mAHD)	Developed (mAHD)	Impact (m)	Existing (mAHD)	Developed (mAHD)	Impact (m)
A	1.537	1.537	0.000	1.535	1.535	0.000	0.868	0.869	0.001
B	2.057	2.062	0.005	1.765	1.785	0.020	1.689	1.702	0.013
C	2.354	2.353	-0.001	2.078	2.083	0.005	2.019	2.045	0.026
D	2.654	2.488	-0.166	2.381	2.227	-0.154	2.312	2.185	-0.127
E	2.669	2.549	-0.120	2.388	2.255	-0.133	2.319	2.208	-0.111
F	2.672	2.553	-0.119	2.391	2.257	-0.134	2.321	2.211	-0.110
G	2.677	2.563	-0.114	2.394	2.264	-0.130	2.325	2.217	-0.108
H	2.682	2.568	-0.114	2.398	2.267	-0.131	2.328	2.219	-0.109
I	2.707	2.714	0.007	2.469	2.681	0.212	2.412	2.625	0.213
J	4.155	4.072	-0.083	4.093	3.991	-0.102	4.052	3.942	-0.110
K	4.391	4.385	-0.006	4.352	4.359	0.007	4.338	4.351	0.013
L	4.332	4.275	-0.057	4.255	4.202	-0.053	4.193	4.137	-0.056
M	3.368	3.395	0.027	3.326	3.347	0.021	3.293	3.312	0.019
N	3.261	3.285	0.024	3.223	3.238	0.015	3.193	3.204	0.011
O	2.789	2.812	0.023	2.750	2.764	0.014	2.720	2.730	0.010
P	2.432	2.440	0.008	2.122	2.131	0.009	2.049	2.057	0.008
Q	2.470	2.478	0.008	2.149	2.158	0.009	2.075	2.083	0.008
R	2.479	2.487	0.008	2.156	2.165	0.009	2.082	2.090	0.008
S	2.479	2.488	0.009	2.156	2.166	0.010	2.083	2.090	0.007

5 Floodplain risk management

5.1 ARI 100 year flood immunity

To protect future residents of the proposed development site from both local and regional flood impacts, it is proposed that the earthworks levels for the site will ensure both existing and future flood immunity (in accordance with the requirements of Tweed Shire Council Development Control Plan No. 3). The adopted design criteria provides flood immunity to the design 100 year ARI flood, incorporating future high range climate change impacts including a 30% increase in rainfall intensity and 0.91m sea level rise.

- The eastern precinct (Precinct 5) has a proposed pad level of RL 4.5m AHD, approximately 1.1m above the ARI 100 year high climate change level and 1.3m above the 10% increase in rainfall intensity climate change level.
- The golf course precinct will be designed with pad levels of around RL 4.35m AHD, approximately 0.95m above the ARI 100 year high climate change level and 1.2m above the 10% increase in rainfall intensity climate change level.
- The mid western precinct has indicative pad levels from RL 5m AHD in the west to RL 4.5m AHD in the east, approximately 1.6m to 1.1m above the ARI 100 year high climate change level and 1.8 to 1.3m above the 10% increase in rainfall intensity climate change level.
- The far western precinct has indicative pad levels of about RL 5m AHD, approximately 0.7m above both the ARI 100 year high climate change and 10% increase in rainfall intensity climate change levels.

Table 5.1.1 (end of this section) summarises the key results for the ARI 100 year (existing climate), the ARI 500 year High Climate change (incorporating a conservative 30% increase in rainfall intensity) and the PMF design floods.

Based on the proposed subdivision earthworks levels, all residential roads will be flood free in the design 100 year ARI flood and are typically set about 500mm lower than the residential pad minimum levels. As such, they will all be above the ARI 100 year high climate change level (which is similar to the existing ARI 500 year flood level) and well above the 10% increase in rainfall intensity climate change level.

The central west area above the lake is a proposed 17 hectare sporting field area, which will be immune from frequent flood events and free draining in compliance with Tweed Shire Council requirements.

5.2 ARI 500 year and PMF flood immunity

The flood modelling results indicate that there are two areas of the floodplain that behave differently to the general floodplain due to localised runoff characteristics. In general, the floodplain is slow to fill and the peak 100 year, 500 year and PMF levels are controlled by long duration storm events, (critical durations 24 – 36 hours) with peaks occurring after 30 or more hours. This is due to the very large storage within the floodplain which attenuates the rate of rise of flood waters as they fill the available storage.

However in two small sections of significance on the site, the critical design storm that is likely to produce the worst regional flooding is the 6 – 9 hour design storm. These localised areas include a small section of waterway near Reardons Road and another near the Tropical Fruit World, both toward the northern extent of the flood plain. Both of these areas are important because they must be catered for in planning evacuation routes to flood free land north of the subdivision.

The results of these analyses indicate that the proposed subdivision roads will all be trafficable for all events up to and including the 100 year climate change flood and for the ARI 500 years existing situation design flood.

The results also indicate that the design deck levels of the various bridges throughout the subdivision will be crucial to ensuring the evacuation routes are kept open for as long as

possible. Deck levels will be set to an appropriate level during the detailed design process.

5.3 Implications of flood evacuation planning criteria on design subdivision and bridge deck levels

To ensure adequate evacuation routes are available during rare and extreme floods, it is necessary to provide as long a warning time to the public as possible. General emergency management experience, based on numerous natural disaster events worldwide, indicates that the majority of people will not voluntarily evacuate and will tend to wait as long as possible before they can be convinced, or are forced to leave.

It is therefore essential that the best advice possible is given to residents in potentially flood

prone areas. The incorporation of the draft activation sequencing recommended in this report into the Local Disaster Plan by Council, SES and Police, should maximise the future success of these strategies.

The next most important thing is that the roads and bridges are available for as long as possible, within reason, during an actual flood event.

While it is not possible to provide high level flood immunity for all roads and structures, the critical links, and generally the lowest points along the evacuation network, are most likely to be at the waterway crossings.

Table 5.3.1 shows the level of flood immunity and evacuation route availability that can be achieved by adopting various road bridge levels at key

Table 5.3.1 Considerations regarding general availability of bridges for flood evacuation

Min. bridge deck/road level (m AHD)	Time to peak 100 year flood level (hrs)	Time to peak 500 year flood level (hrs)	Time to PMF flood level (hrs)	Available evacuation time (hrs)	Comments
2.90	35	15	12.5	Not available	Limited rigid vehicle access after 1.75hrs in PMF
3.15	Flood immunity above RL 2.92m AHD	19	14.25	1.75	Closed after 5.5hrs in PMF
3.40		72	18	5.50	Closed after 7.5hrs in PMF
3.65		Flood immunity above RL 3.45m AHD	20.50	7.50	Closed after 9.25hrs in PMF
3.90			22.25	9.25	Closed after 11.25hrs in PMF
4.15			23.75	11.25	Closed after 12.75hrs after PMF
4.40			25.25	12.75	Closed after 26.5hrs after PMF
4.65			26.50	14	Closed after 27.5hrs in PMF
4.90			27.75	15.25	Closed after 29hrs in PMF
5.15			29.25	16.75	Closed after 31hrs in PMF
5.40			30.75	18.25+	Deck would be awash but probably trafficable in PMF

points within the subdivision. Based on this analysis, it is recommended that the general road bridge links between the precincts should ideally be set at a level the same as the minimum road level within the precincts at RL 3.5 m AHD. At an absolute minimum, a level of RL 3.4 m AHD would provide approximately 18 hours of normal vehicle access during the PMF and would still be trafficable by high vehicles during an ARI 500 year design flood event. This would provide a minimum of 6 – 8 hours of effective evacuation time after the evacuation trigger level is reached.

The only exception to this should be at the two areas controlled by shorter duration localised flooding. These include a potential evacuation link to Reardons Road which should be provided with a minimum deck level of RL 4.1 m AHD, and to the potential link to the north west, in the vicinity of the Tropical Fruit World, where the recommended deck level should be above RL 4.4 m AHD.

Along the existing road profile, the actual road levels of the main access road to the north east, as constructed, are at approximately 3.14m AHD. Based on this, this access road and evacuation route will be available in the ARI 500 year design flood, but would be cut within 6 hours of an evacuation notice being issued in accordance with the criteria set above.

For this reason, the most viable potential flood free links are to the north via Reardons Road, subject to further investigation, and to the north west and west, provided the internal subdivision bridges are constructed at a level above RL 3.4m AHD.

It should be noted that these recommended levels are based on trafficability criteria only. It is expected that there will be other bridge design criteria related to design loads, standards of service, minimum clearance between design flood levels and the soffits of structural elements, as well as dimensional considerations of girders and deck slabs, that will mean these design deck levels are easily met or exceeded.

5.4 Flood evacuation planning

Tweed Shire Council requires that all housing located in potentially flood prone land is provided with safe egress routes to flood free refuges.

Flood prone land is defined as being land below the Probable Maximum Flood. (PMF). The probable maximum flood is usually taken, for practical planning purposes, as a flood that would only be exceeded, in the balance of probability, once in approximately 10,000 to 100,000 years.

Such floods are considered to be so rare that it would in fact be meaningless to quantify them in terms of probability. Based on current trends, it is most likely that design sea levels and rainfall data will change markedly over time, so it is difficult to actually quantify the potential effects of such large floods with any certainty at all.

Design PMF flood levels for this site indicate that the majority of the site is flood prone in the design PMF event. Based on the design pad and road levels provided, it is expected that the majority of slab on ground dwellings would experience above floor flooding to a depth of approximately 550- 650 mm in such a rare circumstance. The only effective strategy to counter the potential effects of such large floods on the safety of the human population at risk in such events is the implementation of a well structured flood warning and evacuation strategy.

The analysis of the rate of rise and time history plots for the ARI 100 year, ARI 500 year and PMF design flood events indicates that there is sufficient time to implement an effective evacuation strategy. Two critical factors in this will be the provision of bridges with decks set at an appropriate level to match the available warning time, activation time and evacuation time requirements.

Early lead time for evacuation planning should be based on rainfall data and rate of flood level rise, both of which can be monitored in real time with currently available technology. For the purposes of analysis it is assumed that as the community expects to be flood free in the design ARI 100 year flood, that no activation of any evacuation plan would be likely to occur until an actual flood reaches the design flood level and the rate of rise and rainfall data and flood level data indicate that it will continue to rise. Rainfall data and flood level data provide the earliest possible trigger for an effective evacuation strategy.

In any flood event, as the flood reaches maximum stage, the rate of rise slows down and approaches zero at the peak of the flood. Data related to the actual flood behaviour during real time as it approaches critical trigger levels provides an excellent second trigger for evacuation planning.

The third critical planning factor to consider in evacuation planning is time to peak. In the design ARI 100 year flood, the actual flood peak is most likely to occur after 24 – 30 hours. However, during the 500 year and PMF floods, the 100 year peak flood level will be reached much earlier in the flood, with water levels continuing to rise rather than coming to a static level. In these events, the designated trigger levels will be likely to occur approximately 19 hrs and 12.5 hours into the flood respectively, with the flood levels still rising.

The proposed road levels throughout the subdivision are generally above RL 3.5m AHD and provide flood free immunity in the design ARI 500 year flood. To ensure the safety of residents in the event of a larger flood, the following triggers are proposed for evacuation purposes, and in the following order:

- Alert Level One: Actual rainfall exceeds the 100 year ARI design rainfall and it is continuing to rain. Activation of evacuation response plan.
- Alert level two: Actual flood level reaches or exceeds the design ARI 100 year flood in less than 24 hours and the water level is still rising. Activation of evacuation notices to residents to be on standby and prepare for evacuation. Evacuation of sick, elderly and at risk groups and early voluntary evacuation to begin as soon as possible after reaching this stage.
- Alert Level Three: If actual rainfall exceeds the ARI 500 year design rainfall or water level is still increasing and rate of rise data indicates less than 6 – 8 hours before roads or bridges will be cut, then general evacuation should commence.

Table 5.1.1 Summary of available major flood data and general flood immunity

Reporting point	Minimum pad level/ road level (RL m AHD)	ARI 100 year flood level (RL m AHD) – Existing climate	ARI 500 year high climate change flood characteristics (RL m AHD)	PMF flood characteristics (RL m AHD)	Flood evacuation status
Eastern precinct (Stage 1 development)	Pads RL 4.5 Roads RL 4.0 Bridge deck to western precinct not designed. Bridge deck to north east at RL 3.14m AHD.	ARI 100 yr RL 2.55 m at north eastern access bridge. Generally RL 2.92 m AHD elsewhere. RL 3.68 at Reardons Rd	ARI 500 yr RL 3.19 m upstream of access bridge peaks in 30 hrs. Reaches early peak at 100 yr level in 6 hrs then again at 16 hrs. Rises slowly to peak over next 13 hours. At Reardons Rd reaches peak <100 yr level after 8 hours then drops very slowly for next 42 hours.	PMF level RL 5.31 at access bridge and generally RL 5.66 elsewhere. Peaks in 35 hrs approx. Reaches 100 yr levels in approx 12 – 16 hours. Rises over next 6 – 7 hrs to peak in 19 to 22 hrs. At Reardons, rises to ARI 100 level in 8 hrs then rises slowly to peak	House pads and roads flood free up to ARI 500 year level. During PMF, flood levels reach RL 4 after 23 hrs. All roads below RL 4 cut after 24 hrs. Main access bridge to north east cut after 19 hours giving only 5.5 hours usage after 100 year flood level trigger.
Golf course precinct	Pads RL 4.35. Roads RL 3.85. Deck of bridge approx RL3.5 m AHD	ARI 100 yrs RL 2.92 m AHD. Peaks in 35+ hours. House pads and roads flood free in ARI 100 yr flood	Q500 level RL 3.44 m AHD. Peaks in 29-30 hours. All roads flood free in 500 yr event. Reaches 100 yr ARI flood level in 15-19 hrs. Rises very slowly from the ARI 100 yr flood level from 65 mm/hr to zero at peak	PMF RL 5.66 m AHD. Reaches ARI 100 yr level in approx 12.5 hrs. Reaches deck level (3.5m) of bridge in 18.75hrs. Bridge closed at 20 hours	Roads have general 500 year immunity. Evacuation routes open for approx 6 hours after 100 year trigger level in PMF. All roads below RL 3.85 m cut after 23.5 hrs. House pads inundated after 25 hrs
Mid western precinct	Pads RL 5.0, roads RL 4.5. Recommended	Reardons peak ARI 100 yr = RL 3.68 m AHD	In 500 yr ARI does not reach 100 yr peak level at	PMF at all locations approx RL 5.66 peaking	Bridge to eastern precinct cut after approx 21 hrs.

Reporting point	Minimum pad level/ road level (RL m AHD)	ARI 100 year flood level (RL m AHD) – Existing climate	ARI 500 year high climate change flood characteristics (RL m AHD)	PMF flood characteristics (RL m AHD)	Flood evacuation status
	bridge deck levels to be at least RL 3.5 m AHD and at Reardons Rd, approx RL 4.1m AHD	peaking in 3 hrs and 30 hrs. Elsewhere generally RL 2.92 m peaking 35.5 hrs. House pads and roads flood free in ARI 100 year event.	Reardons Rd. Elsewhere generally peaks at RL 3.44 m at approx 30 hrs. Reaches 100 yr level after 15 hrs. Generally all roads and pads flood free.	slowing in 34.5 hrs. Reaches Q100 level in approx 12.5 hrs.	Roads below RL 4.5 cut after 27 hrs. House pads flooded after 28.5 hrs.
Far western precinct	Pads RL 5.0. Roads RL 4.5. Recommended bridge deck levels to west and north west to be at least RL 4.5 m AHD	Reardons Rd peak ARI 100 yr = RL 3.68 m AHD peaking in 3 hrs and 30 hrs. Elsewhere generally RL 2.92 m peaking at 35.5 hrs.	In 500 yr ARI does not reach 100 yr peak level at Reardons Rd. Elsewhere generally peaks at RL 3.44 m at approx 30 hrs. Reaches 100 yr level after 15 hrs. Generally all roads and pads flood free	PMF at all locations approx RL 5.66 peaking slowing in 34.5 hrs. Reaches Q100 level in approx 12.5 hrs.	Bridge to eastern precincts cut after approx 21 hrs. Roads below RL 4.5 cut after 27 hrs. House pads flooded after 28.5 hrs.

6 Conclusions

Detailed flood modelling for the existing site and under proposed future development scenarios for both existing and future climate change situations has been carried out. Flood level predictions have been based Tweed/Byron Coastal Creeks Flood Study Tuflow model. (Final Report Nov 2009).

The flood study results indicate that the development site is subject to potential flooding from both local and regional runoff events. Flooding is also influenced by potential sea level rise, storm surge and climate change effects.

Based on the studies and investigations carried out to date, we conclude that:

- The majority of the proposed development is above current flooding influence and future climate change affected flooding.
- Only floodplain fringe filling is proposed.
- No significant adverse off site impacts are predicted.
- Habitable flood levels have been set a minimum of 0.7m above the upper limit high climate change (0.91m sea level rise plus 30% increase in rainfall intensity) ARI 100 year case (and therefore also above the 10% increase in rainfall climate change level).
- The internal road network can be designed to provide flood free access up to the design ARI 100 year high climate change flood and can also provide flood free access generally up to the ARI 500 year flood.
- Appropriate and safe emergency evacuation routes can be provided in association with an early warning system to trigger activation of an evacuation plan in the rare event of an actual flood that is likely to exceed the design ARI 100 year flood.
- Flood velocities are low and non-scouring and generally less than 0.5m/s and as such are not likely to pose any significant risks to the public or to private and public infrastructure.

7 Qualification

This report has been prepared by G&S specifically for Project 28 Pty Ltd, to provide advice on flooding in relation to the Project Application for the Kings Forest development, located in Kings Forest, New South Wales. As such its use is limited to this purpose and may not be applicable beyond this scope.

In preparing this report, we have relied on information provided by others, including:

- Site survey supplied by Mortons Urban Solutions.
- Concept Plan provided by MPS architects dated October 2009.
- Preliminary civil design carried out by Mortons Urban Solutions.
- Recent Council decisions in relation to the levels set for minimum habitable floor levels and road levels.

Whilst the MPS Concept Plan (October 2009) was updated in June 2011, the changes were of no consequence for the purposes of the flood modelling reported herein.

The accuracy of this report is limited to the accuracy of this information. While G&S's report accurately assesses flooding from design storms, future observed flood levels may vary from the predicted, depending on the accuracy of rainfall/runoff.

Our analysis and overall approach has been specifically to cater for the particular requirements of Project 28 and may not be applicable beyond this scope. For this reason any third parties are not authorised to utilise the report without further input and advice from G&S. Third parties should therefore seek advice from G&S on applicability for any other use.

8 Attachment 1 - Drawings



SCALE
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ORIENTATION
NORTH

LEGEND

— Site boundary

SOURCES

Image Source: Cudgen 9641-S-N 1:25 000
Topographic and Orthographic Map



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PROJECT NO	10468					

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ORIENTATION
NORTH

LEGEND

- Site boundary
- Catchment boundary
- Flowpath

SOURCES
Image source: Google Earth
Imagery date: August 15, 2008



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AGRICULTURE WATER ENVIRONMENT

PROJECT
KINGS FOREST STAGE 1
PROJECT APPLICATION
FLOOD AND FLOOD
MANAGEMENT ASSESSMENT

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DRAWING
LOCAL CATCHMENT PLAN

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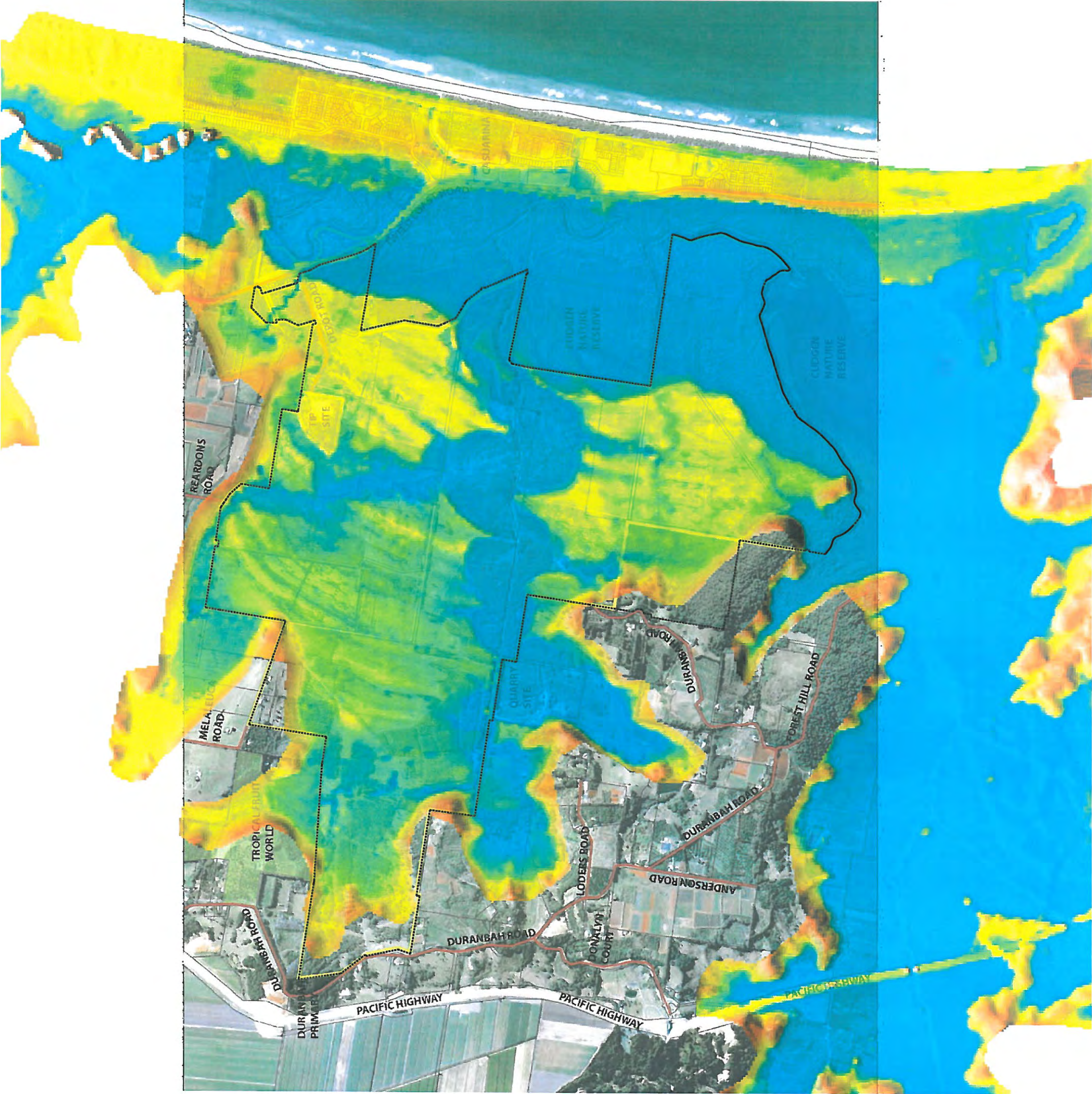


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ORIENTATION
NORTH

LEGEND

Topography
(mAHD)



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FLOOD AND FLOOD
MANAGEMENT ASSESSMENT

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DRAWING
EXISTING SITE TOPOGRAPHY

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ORIENTATION
NORTH

LEGEND

Topography
(mAHD)



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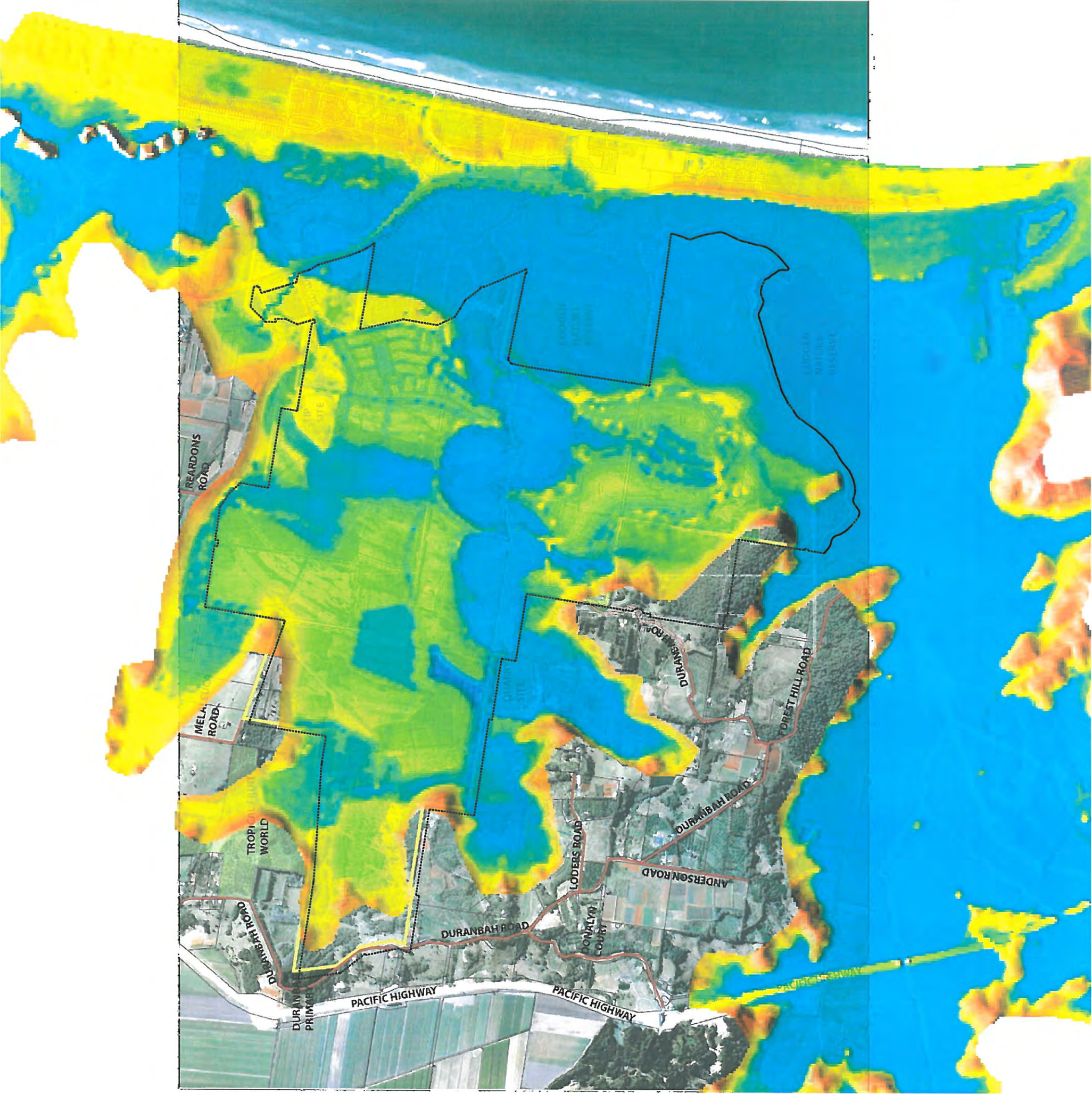
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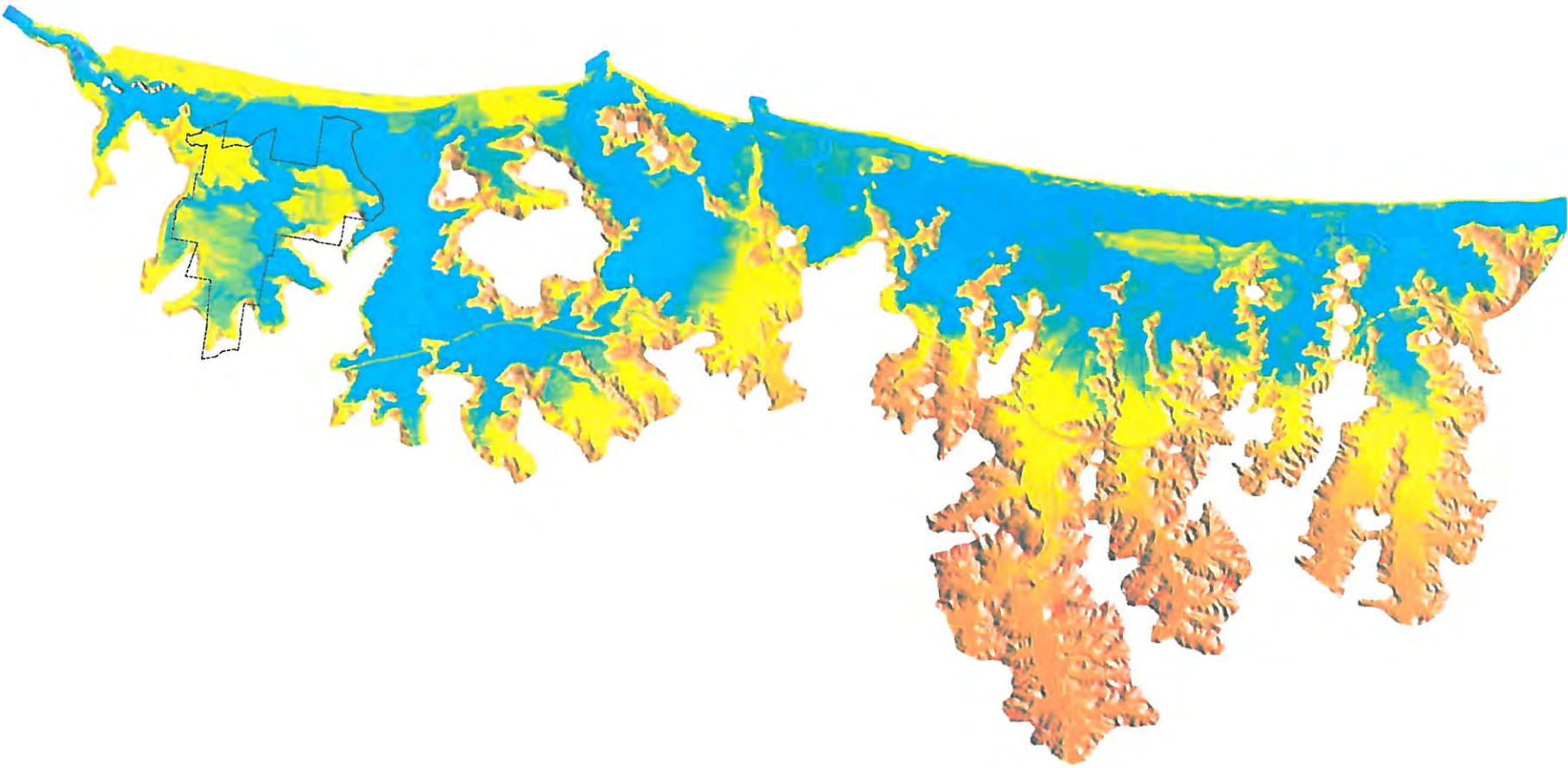
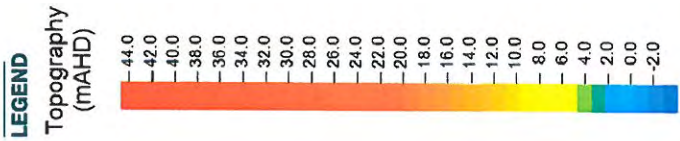
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PROJECT

KINGS FOREST STAGE 1
PROJECT APPLICATION
FLOOD AND FLOOD
MANAGEMENT ASSESSMENT

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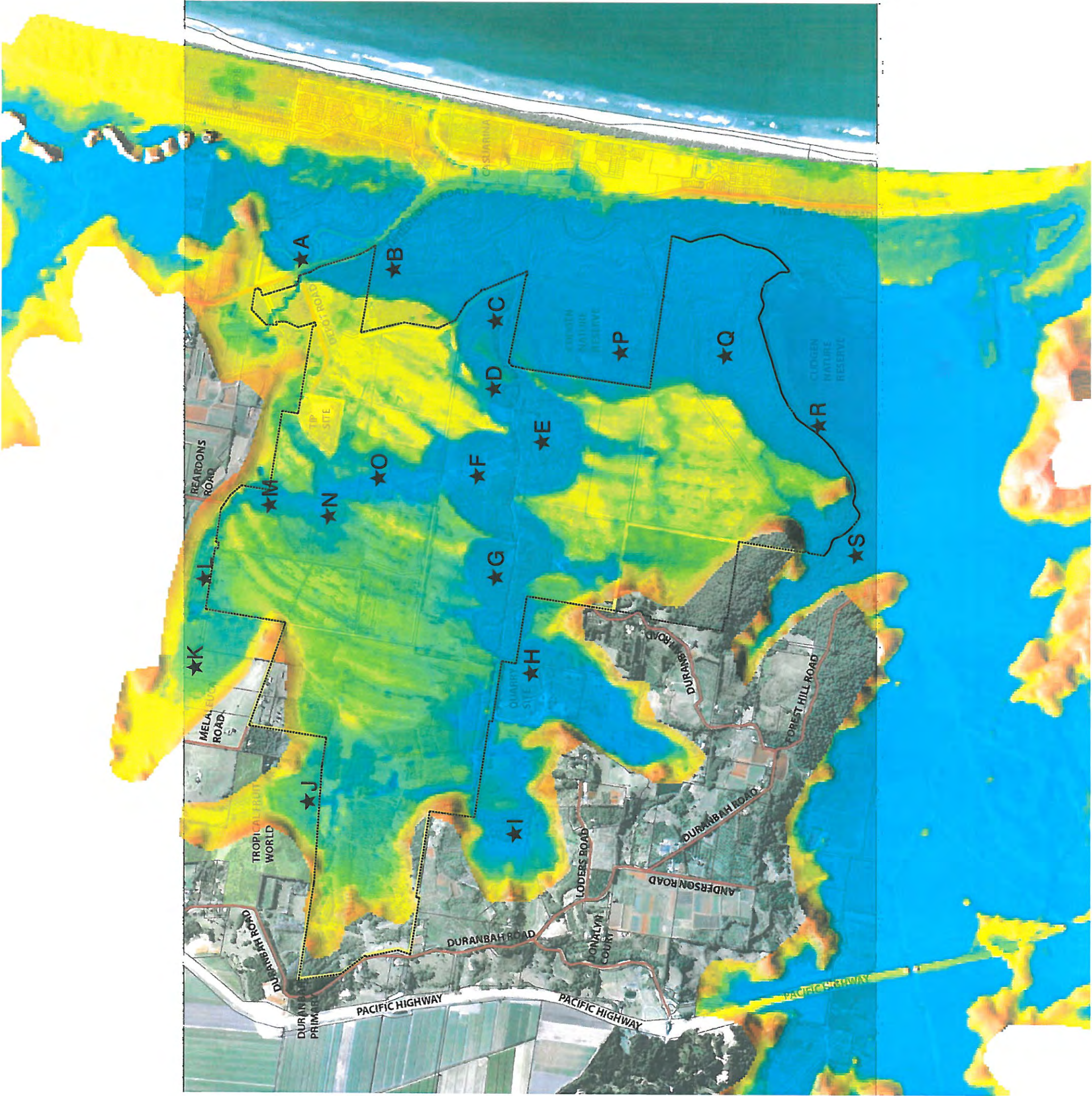
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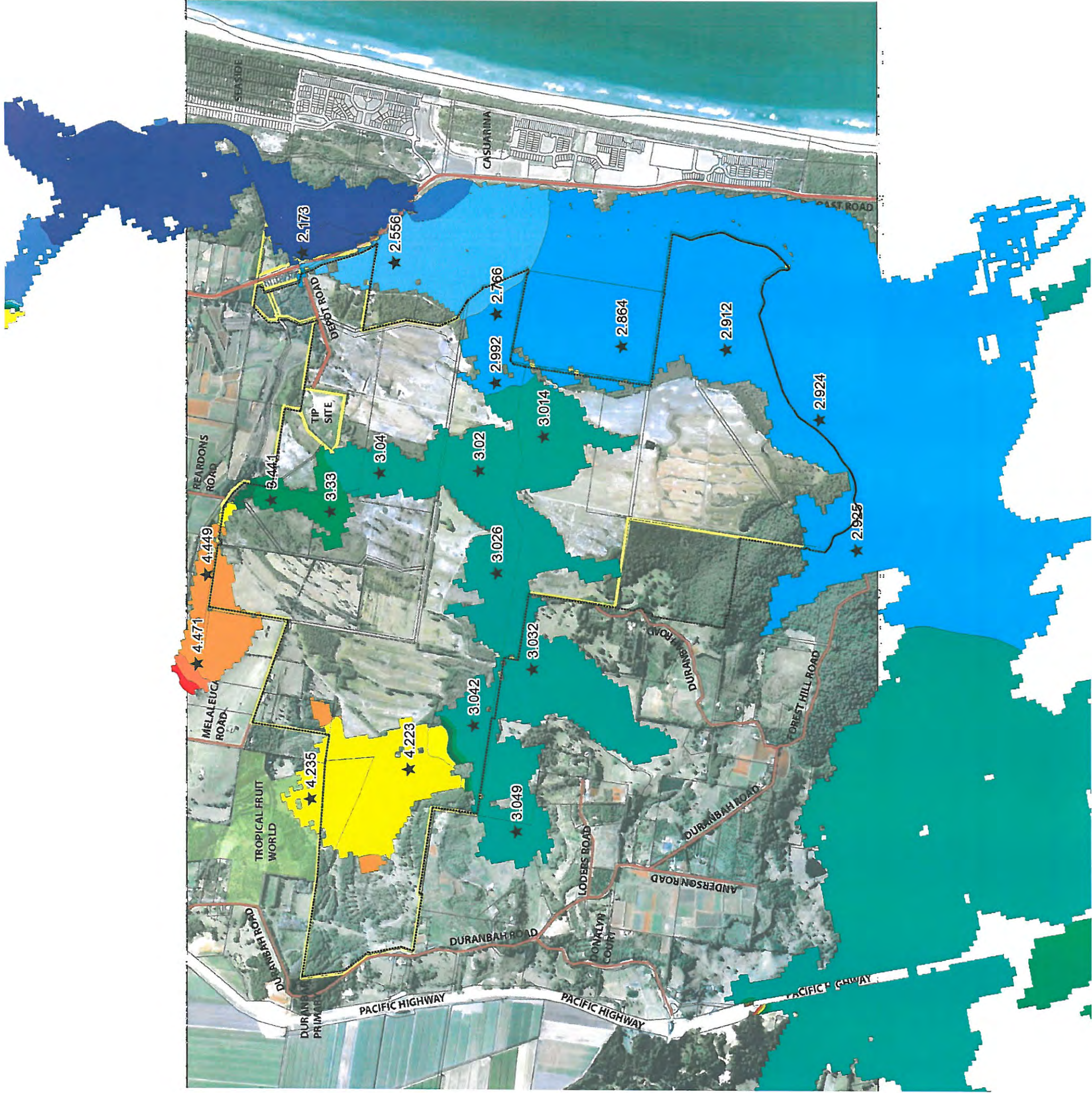
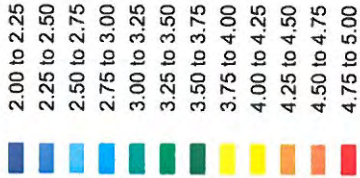
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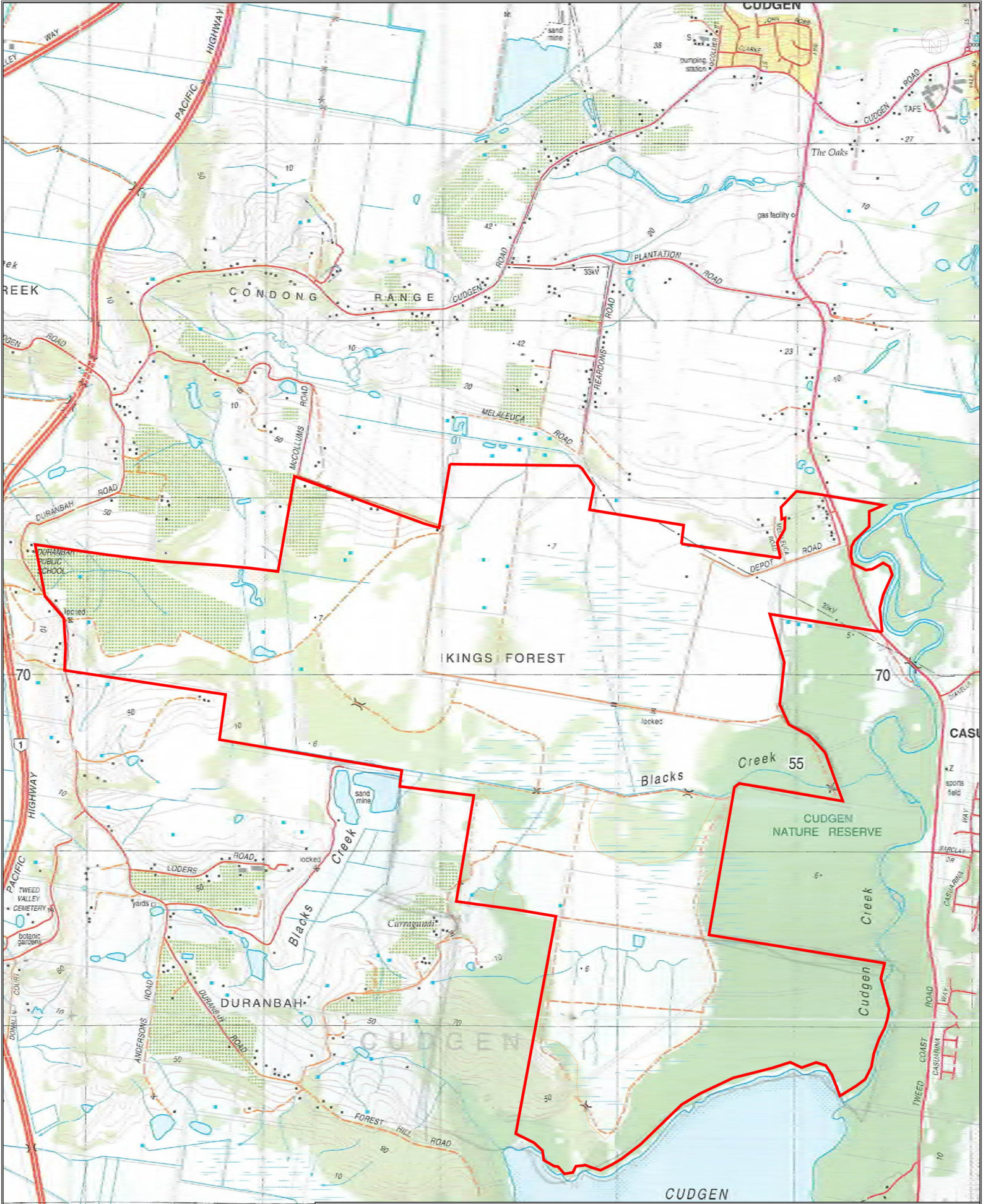
Topography
(mAHD)



LEGEND

Water Surface Levels
(mAHD)





NOTES:
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TOPOGRAPHIC AND ORTHOGRAPHIC MAP

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KINGS FOREST PROJECT APPLICATION

LOCAL HYDROLOGICAL ASSESSMENT

SITE LOCATION

SCALE AS SHOWN

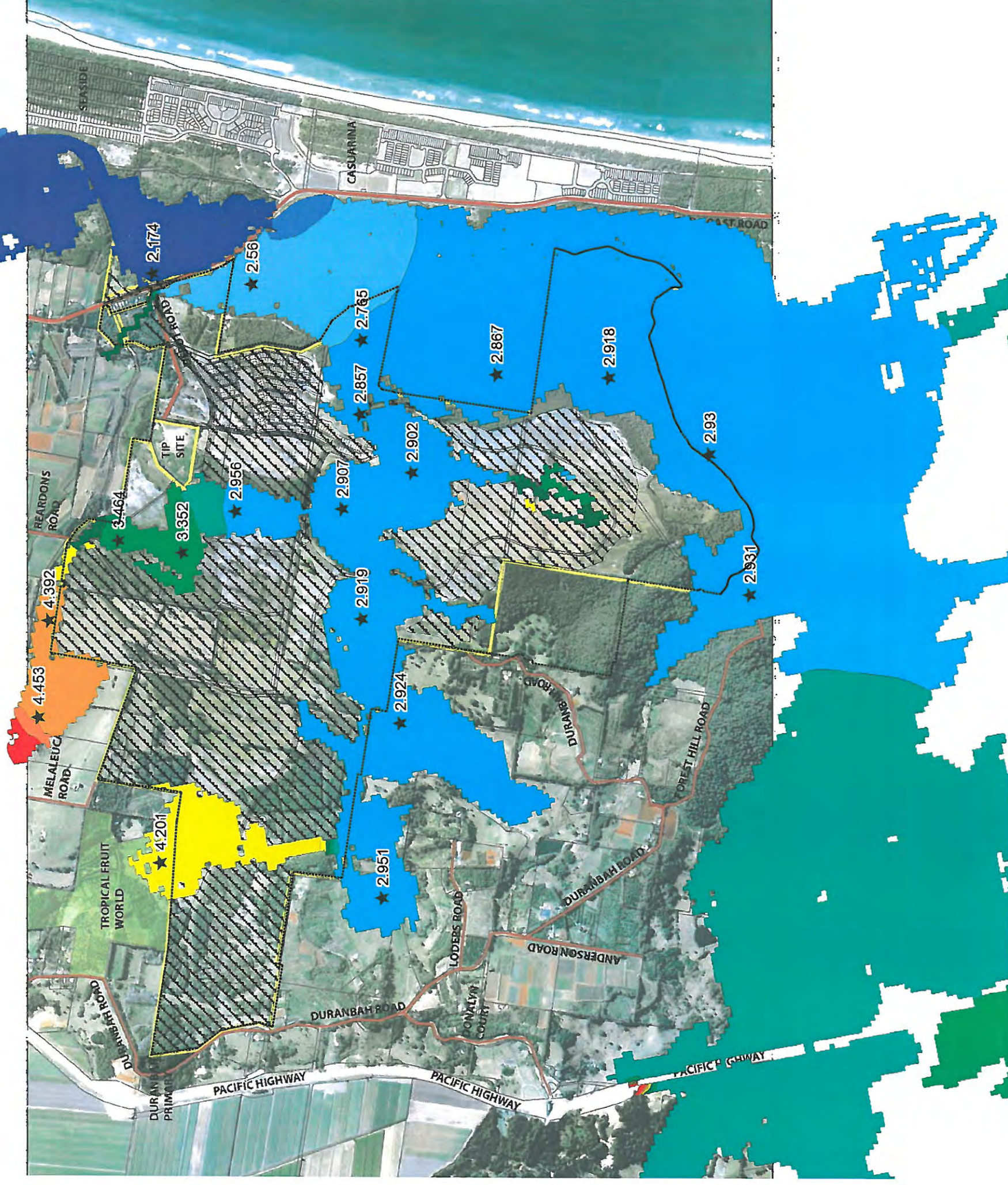
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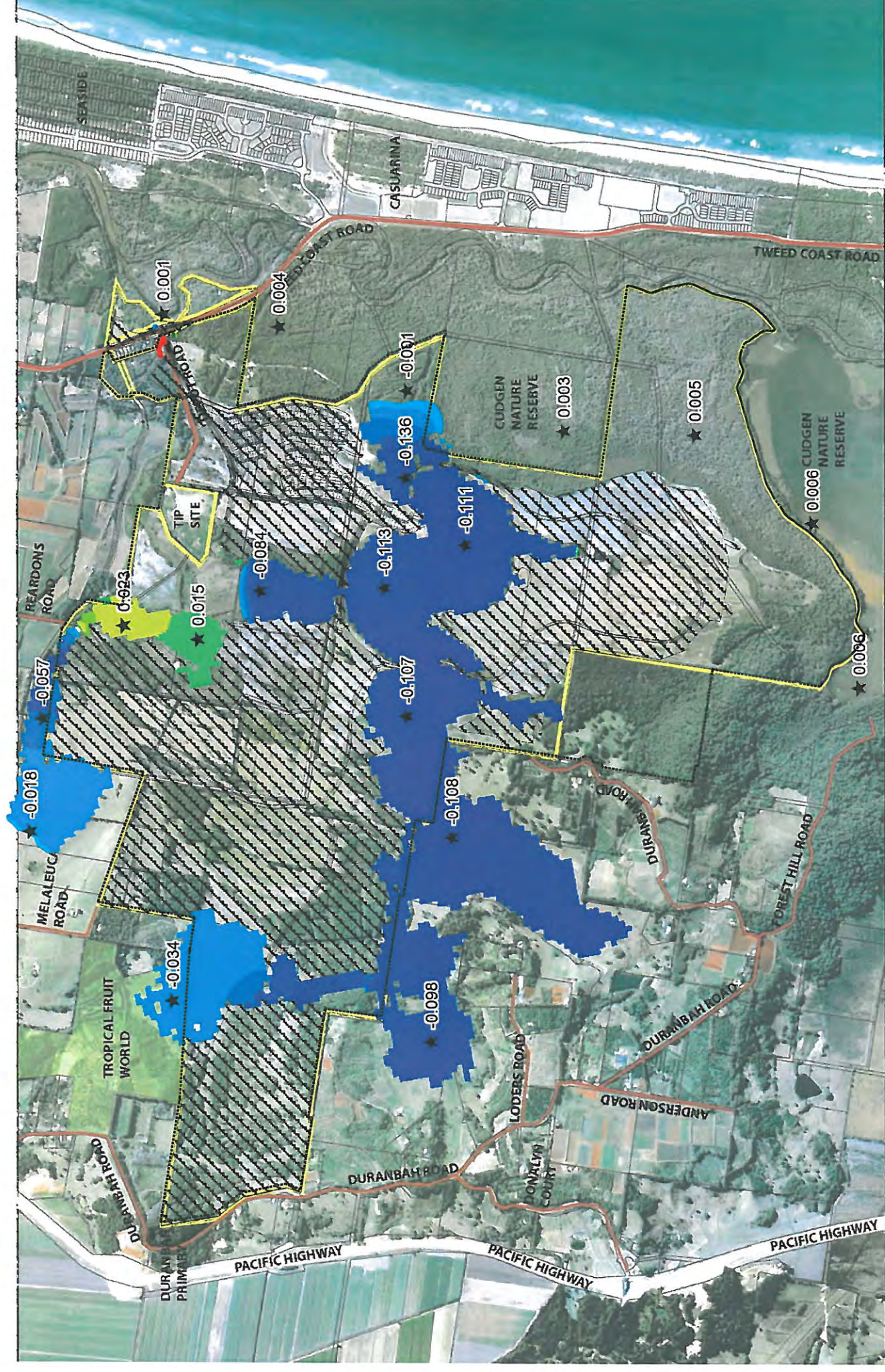
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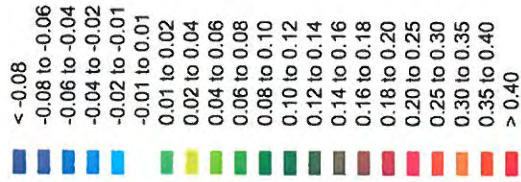




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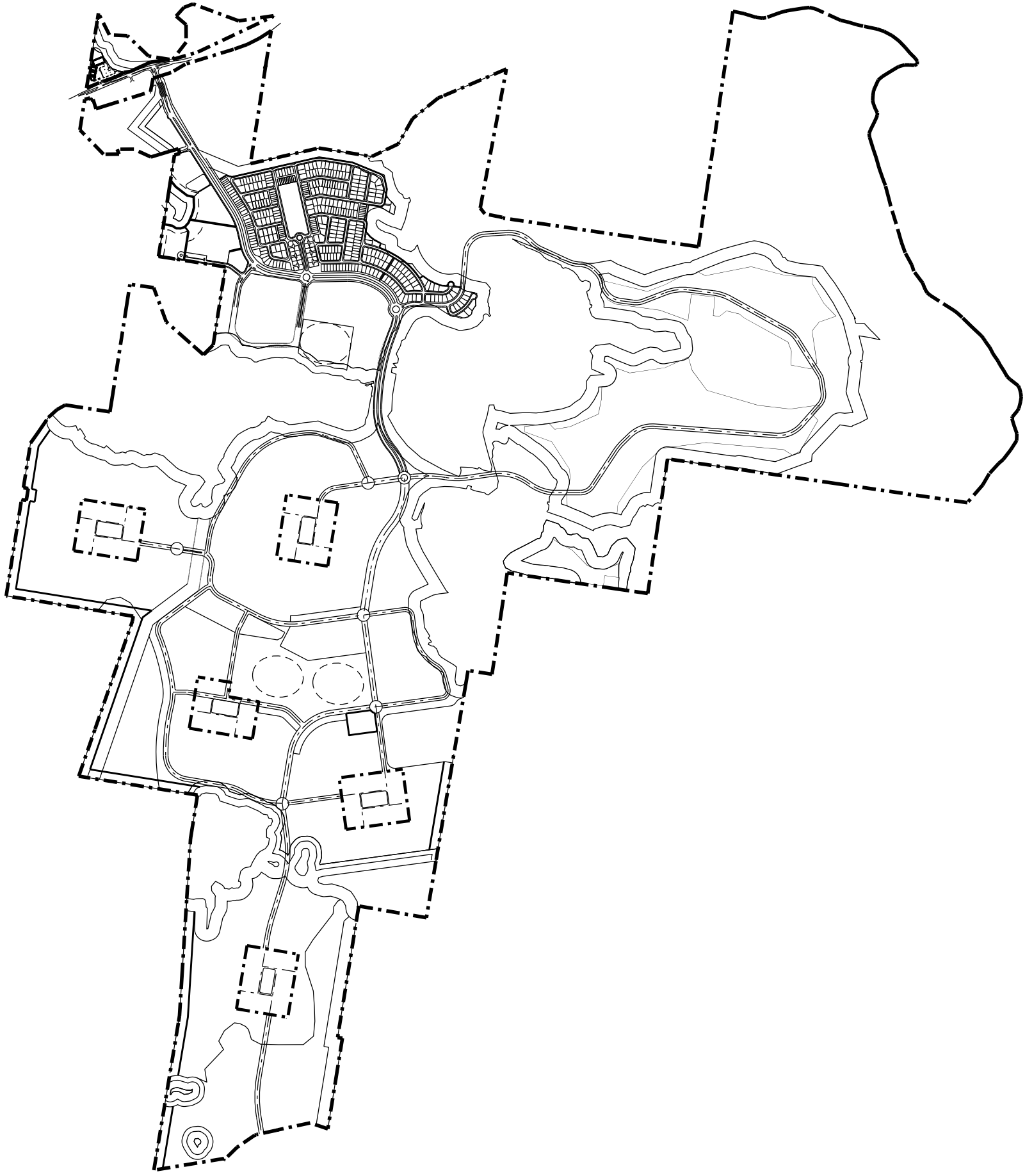
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AGRICULTURE WATER ENVIRONMENT

9 Attachment 2 – Reference drawings

Kings Forest Master Plan – MPS Architects – Drawing MPS 2142 MP-01 December 2010

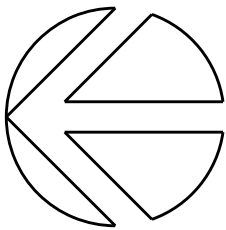


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10 Appendix 1 – ‘Flood Assessment, Kings Forest, Kingscliff, NSW’ (Gilbert & Sutherland, December 2009)

**Flood Assessment
Kings Forest
Kingscliff, NSW**

Prepared for:
Project 28 Pty Ltd

December 2009

Document control

Document:	KJ0224-1_FLD_RIC2F.doc	Gilbert and Sutherland P/L ABN 56 077 310 840 Originating Office: Robina Eastside 5/232 Robina Town Centre Drive, Q4226 PO Box 4115, Robina Q4230 Telephone 07 5578 9944 Facsimile 07 5578 9945 gsrobina@groupgs.com Also at Kawana and Brisbane
Title:	Flood Assessment, Kings Forest, Kingscliff, NSW	
Project Manager:	Neil Collins	
Author:	Ian Clark	
Client:	Project 28 Pty Ltd	
Client Contact:	Reg van Rij	
Client Reference:		
Synopsis:	This report describes assessments of flooding characteristics for the proposed Kings Forest development under existing and proposed developed conditions.	

Revision History

Revision #	Date	Edition By		Approved By	
1	22/12/09	IQC			

Distribution

	Revision Number									
Distribution	1	2	3	4	5	6	7	8	9	10
Project 28 Pty Ltd	1									
G&S library and file	2									

Summary

Gilbert & Sutherland Pty Ltd (G&S) was commissioned by Project 28 Pty Ltd, a subsidiary of Leda Developments (LEDA), to undertake specialist studies and assessments in support of a Part 3A Project Application. These studies have been undertaken to provide responses to the Director General's Environmental Assessment Requirements for Project Application No. 08_0194, dated October 14, 2008.

This report describes assessments of flooding characteristics associated with the site for the existing and proposed developed conditions. The assessment covers both Cudgen Creek regional flooding, storm surge and local catchment flooding in combination. A separate report detailing local catchment hydrology has also been prepared.

An assessment of the potential climate change impacts on flood level has also been carried out. The sensitivity assessments were based on those outlined in the NSW Department of Environment, Climate Change and water (DECC) publication, 'Practical Consideration of Climate Change', 2007. The scenario used for the sensitivity analysis included the combination of +0.91m rise in sea level and a 30% increase in rainfall intensity over the entire catchment.

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KJ0224.1.1	Site location
KJ0224.1.2	Existing model topography
KJ0224.1.3	Developed model topography
KJ0224.1.4	TUFLOW model extent
KJ0224.1.5	Reporting point locations

1) Introduction

Gilbert & Sutherland Pty Ltd (G&S) was commissioned by Project 28 Pty Ltd, a subsidiary of Leda Developments (LEDA) to undertake specialist studies and assessments in support of a Part 3A Project Application. These studies have been undertaken to provide responses to the Director General's Environmental Assessment Requirements (DGRs) for Project Application No. 08_0194, dated October 14, 2008 and to support the associated project

application in relation to the management of local flooding.

This report describes assessments of the local and regional flooding and the potential impact with which the proposed Kings Forest development will have on these levels.

This assessment has been based on existing survey data and preliminary civil design details for the proposed works provided by Mortons Urban Solutions.

2) Site description and proposal

2.1 Location

The site for the proposed development occupies approximately 870ha and is located in Kingscliff, on the NSW far North Coast. The site is bounded by Depot Road to the east and Duranbah Road to the west.

The site location is shown on Drawing No. KJ0224.1.1.

2.2 Receiving environment

The land ranges in elevation from approximately RL0m Australian Height Datum (AHD) to RL55m AHD.

Runoff from this development generally flows in an easterly direction via a number of unnamed ephemeral gullies and SEPP14 wetlands into Cudgen Creek. Cudgen Creek flows from Cudgen Lake which lies to the south-east of the site to its mouth at Kingscliff approximately 4.5km to the north-east of the site.

2.3 Existing development

The site has been selectively cleared. A large portion of the site was used as a pine plantation which has recently been harvested and removed.

There are a number of dwellings and farm sheds on the subject land.

2.4 Proposed development

The Kings Forest Concept Plan proposes the creation of a residential community inclusive of associated educational, social, commercial, sporting and recreational amenities. The development would be completed in stages and would include substantial areas of open space which would provide substantial riparian buffer areas to the SEPP14 wetlands Cudgen Creek and Cudgen Lake.

Given that the present application is for approval of a concept plan, detailed road and allotment layouts have not been completed for the whole of the project, however preliminary bulk earthworks design, site grading and drainage design has been prepared. The proposed concept plan, prepared by MPS Architects is included as a reference drawing to this report.

The ultimate proposed development includes the construction and/or installation of the following components:

- site earthworks
- roads / trafficable areas
- stormwater drains
- sewer reticulation mains
- water reticulation mains
- underground electricity distribution cables
- telecommunications cables
- other ancillary services
- construction/building works
- landscaping.

3) Flooding assessment

3.1 Methodology

To assess the extent of flooding that the site currently experiences, G&S has utilised the Tweed-Byron Coastal Creeks TUFLOW 2D flood model, developed by BMT WBM on behalf of Tweed Shire Council. A full description of the model is presented in the Tweed Shire Council/BMT WBM report entitled 'Tweed-Byron Coastal Creeks Flood Study Final Report', November 2009.

Hydraulic modelling was carried out using the BMT WBM's TUFLOW one-dimensional/two-dimensional hydrodynamic flood modelling system, utilising both the one and two-dimensional modelling features. The two-dimensional component allows for accurate portrayal of flow over the floodplain whilst the one-dimensional components accurately represent main channels and various structures within the model area.

In setting up this model our approach has been to:

- Review the supplied TUFLOW model data.
- Update the model topography with survey supplied by Mortons Urban Solutions
- Re-run the model for the design storm events including the 5, 10, 20, 50 and 100 year ARI storm events. The PMF and high climate change events were also assessed.
- Produce flood inundation maps of the ARI design storm events for the current site.
- Incorporate the proposed development into the model.
Model the proposed development for the same ARI design storm event to determine flow patterns and flood levels for the site and surrounds.
- Compare the pre and post flood levels to assess potential impacts on peak flood levels.

Drawings numbered KJ0224.1.2 and KJ0224.1.3 provide detail on the base topography and proposed development topography used in the sub-model.

Drawing No. KJ0224.1.4 shows the overall TUFLOW model extent.

Roughness coefficients were based on those within the supplied flood model. The proposed development model incorporated allowance for maintenance works within the existing site drain and assumed a manning's 'n' value of 0.08 for this area.

Discharges and boundary conditions representing the regional design storm events and storm surge were provided with the BMT WBM TUFLOW model. Local catchment flows for the site were obtained from WBNM hydrologic modelling of the local site catchment as detailed the accompanying report, 'Local Hydrological Assessment. Kings Forest, NSW', December 2009.

3.2 Results

Appendix 1 contains detailed results of the flood assessment.

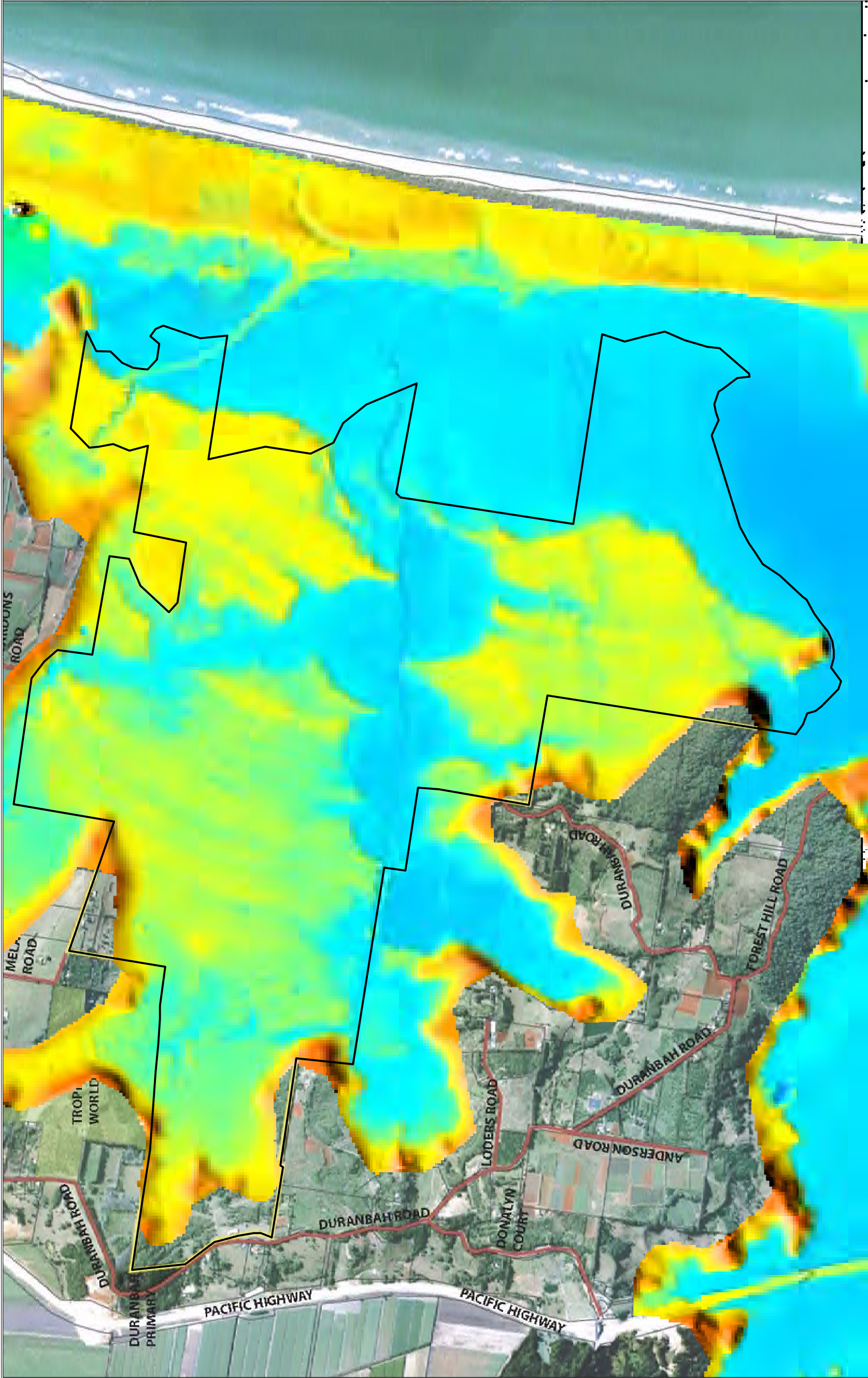
In summary, from the analysis described above, no adverse impacts on peak flood levels for the presented design storm events are experienced as a result of the proposed development. Some minor increases are observed in the two and five year events over a localised area however these impacts will be reduced once further detailed design is carried out.

A predicted climate change assessment was also carried out to provide assistance in setting development levels to take into account the potential for sea level rise and increases in rainfall intensity due to possible future climate change. The scenario run was the high climate change scenario which included the combination of +0.91m rise in sea level and a 30% increase in rainfall intensity over the entire catchment as per the NSW Department of Environment, Climate Change and water (DECC) publication, 'Practical Consideration of Climate Change', 2007.

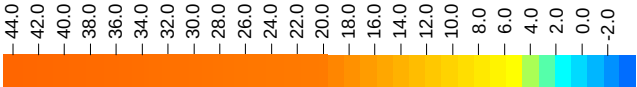
To assist in evacuation planning, a PMF assessment for the site was also conducted. From these results route planning and refuge areas can be determined.

Table 3.2.1 provides a comparison of peak flood levels at selected reporting points

within the site and adjacent areas for a range of flood events. Drawing No. KJ0224.1.5 shows the location of these points.



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(mAHd)



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PROPOSED KINGS FOREST DEVELOPMENT

KINGSCLIFF, NSW

EXISTING MODEL TOPOGRAPHY

SCALE AS SHOWN

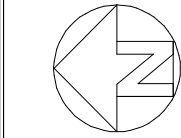
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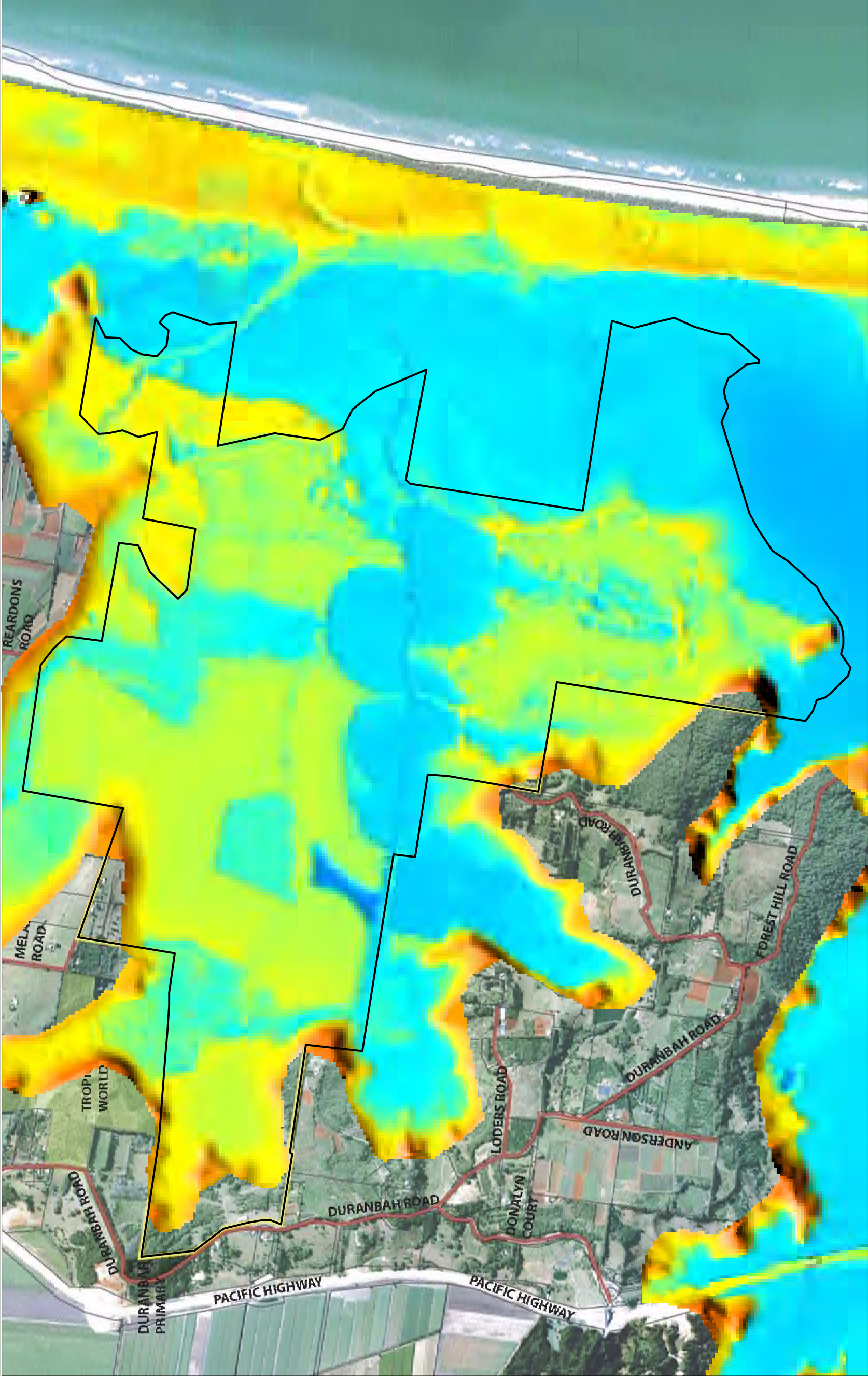
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PROPOSED KINGS FOREST DEVELOPMENT
KINGSCLIFF, NSW
DEVELOPED MODEL TOPOGRAPHY

SCALE AS SHOWN

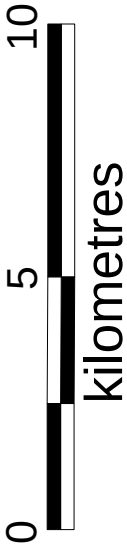
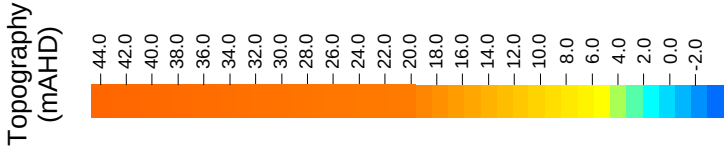
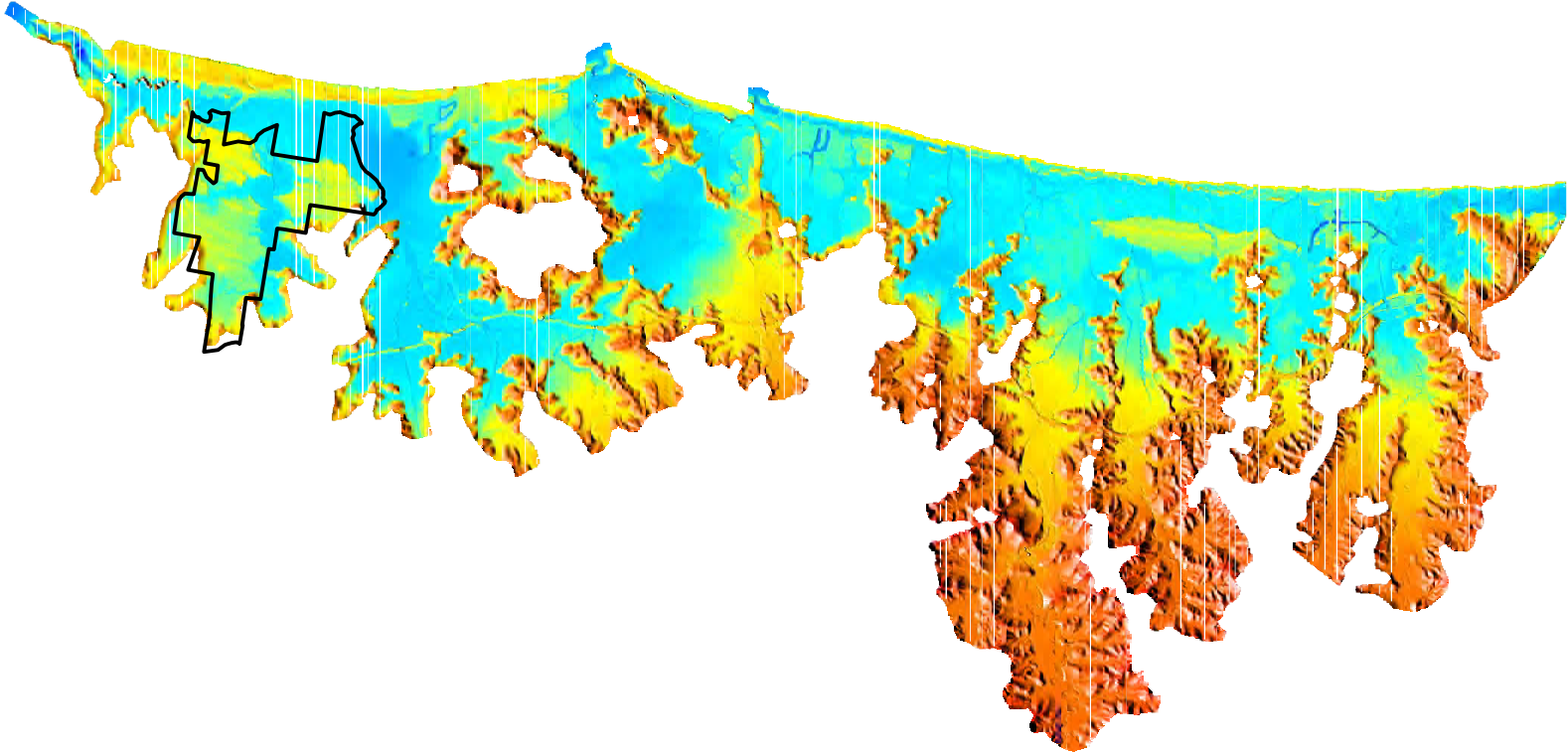
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FIGURED DIMENSIONS TO
BE READ IN PREFERENCE
TO SCALING.

APPROVED

PROJECT

PROJECT28 PTY LTD

PROPOSED KINGS FOREST DEVELOPMENT
KINGSCLIFF, NSW

TUFLOW MODEL EXTENT

SCALE AS SHOWN

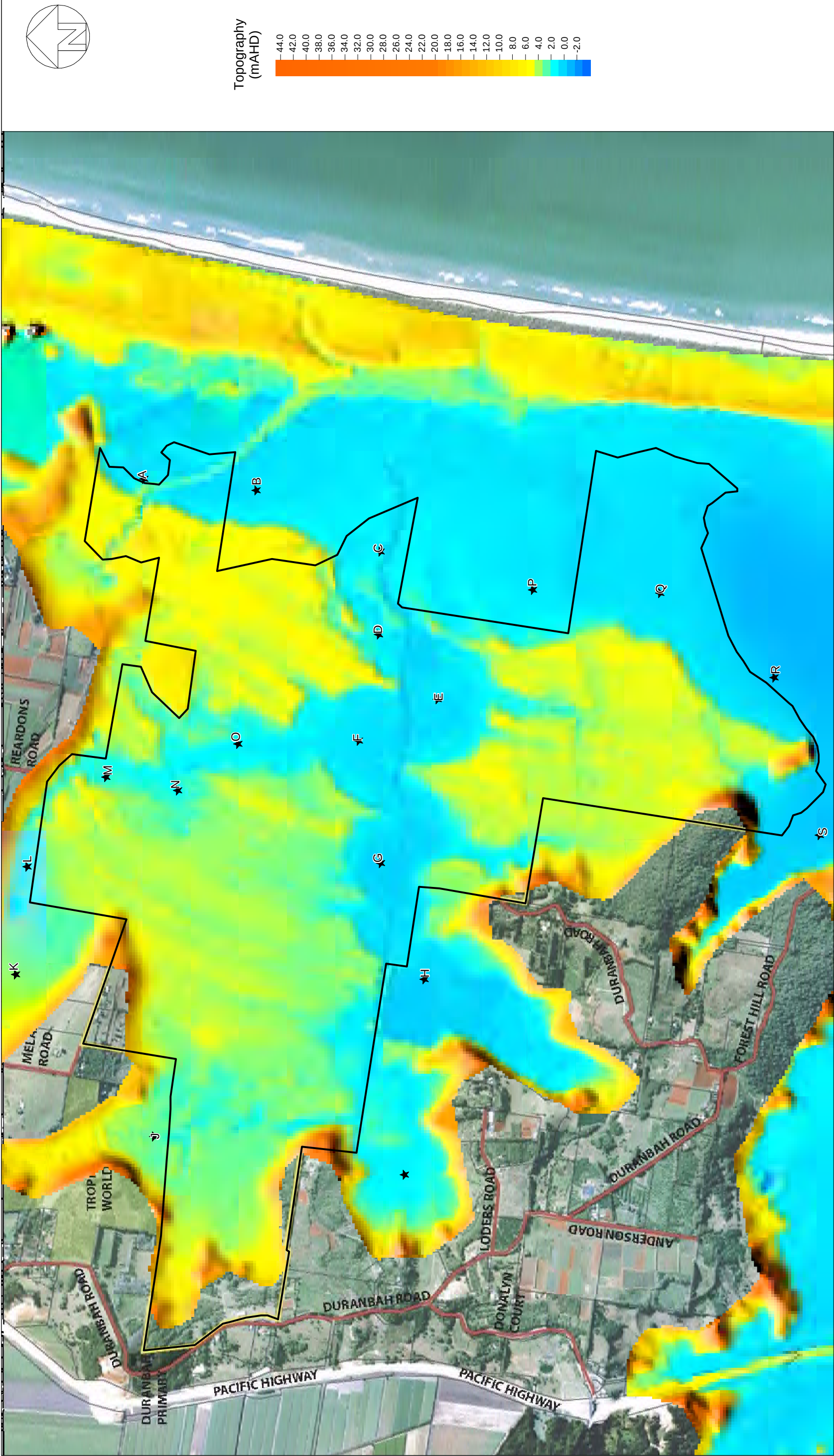
DRAWN I.Q.C

DRAWING No.

DATE 22/12/09

CHECKED

KJ0224.1.4



Topography
(mAHD)



GILBERT+SUTHERLAND
agriculture · water · environment

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PROJECT			
PROJECT28 PTY LTD			
PROPOSED KINGS FOREST DEVELOPMENT			
KINGSCLIFF, NSW			
REPORTING POINT LOCATIONS			
SCALE AS SHOWN	DRAWN I.Q.C	DRAWING No.	
DATE 22/12/09	CHECKED	KJ0224.1.5	

FIGURED DIMENSIONS TO
BE READ IN PREFERENCE
TO SCALING.

APPROVED

4) Conclusions

This study has investigated the effects on flooding of a proposed development and the potential impacts associated with them.

Based on the analysis described herein, the proposed Kings Forest development at Kingscliff, NSW has no adverse impact on peak flood levels for the full range of design storm events. Thus resulting in no adverse impacts on adjacent property owners.

In addition to the design storm event assessments, modelling has also been carried out to assess potential climate change effects, for the purpose of checking development levels against future sea level rise and increased rainfall intensity, as well as PMF modelling to assist in evacuation planning.

5) Qualification

This report has been prepared by G&S specifically for Project 28 Pty Ltd, a subsidiary of LEDA Manorstead Pty Ltd, to provide advice on flooding in relation to the Project Application for the Kings Forest development, located in Kingscliff, NSW. As such its use is limited to this purpose and may not be applicable beyond this scope. Third parties should therefore seek advice from G&S on applicability for any other use.

In preparing this report, we have relied on information by others including:

- Site survey supplied by Mortons Urban Solutions
- Concept Plan provided by MPS architects

- Preliminary civil design carried out by Mortons Urban Solutions

The accuracy of this report is limited to the accuracy of this information. While G&S's report accurately assesses flooding from design storms, future observed flood levels may vary from the predicted, depending on the accuracy of rainfall/runoff.

Our analysis and overall approach has been specifically to cater for the particular requirements of LEDA and may not be applicable beyond this scope. For this reason any third parties are not authorised to utilise the report without further input and advice from G&S.

6) Appendix 1 – Reporting points

Reporting Points		100			50			20			10			5			PMF		100 (High Climate Change)	
	Existing (mAHd)	Developed (mAHd)	Impact (m)	Existing (mAHd)	Developed (mAHd)	Impact (m)	Existing (mAHd)	Developed (mAHd)	Impact (m)	Existing (mAHd)	Developed (mAHd)	Impact (m)	Existing (mAHd)	Developed (mAHd)	Impact (m)	Existing (mAHd)	Developed (mAHd)	Impact (m)	Existing (mAHd)	Developed (mAHd)
A	2.173	2.174	0.001	1.705	1.715	0.010	1.537	1.537	0.000	1.535	1.535	0.000	0.868	0.869	0.001	5.291	5.293	0.001	2.764	2.766
B	2.556	2.560	0.004	2.275	2.278	0.003	2.057	2.062	0.005	1.765	1.765	0.000	1.689	1.702	0.013	5.411	5.413	0.013	3.118	3.119
C	2.766	2.765	-0.001	2.572	2.572	0.000	2.354	2.353	-0.001	2.078	2.083	0.005	2.019	2.045	0.026	5.608	5.612	0.026	3.265	3.264
D	2.992	2.857	-0.135	2.843	2.669	-0.174	2.654	2.488	-0.166	2.381	2.227	-0.154	2.312	2.185	-0.127	5.649	5.647	-0.002	3.362	3.308
E	3.014	2.902	-0.112	2.862	2.743	-0.119	2.669	2.549	-0.120	2.388	2.255	-0.133	2.319	2.208	-0.111	5.662	5.653	-0.009	3.379	3.325
F	3.020	2.907	-0.113	2.867	2.747	-0.120	2.672	2.553	-0.119	2.391	2.257	-0.134	2.321	2.211	-0.110	5.665	5.654	-0.011	3.385	3.327
G	3.026	2.919	-0.107	2.872	2.759	-0.113	2.677	2.563	-0.114	2.394	2.264	-0.130	2.325	2.217	-0.108	5.666	5.655	-0.011	3.391	3.333
H	3.032	2.924	-0.108	2.878	2.764	-0.114	2.682	2.568	-0.114	2.398	2.267	-0.131	2.328	2.219	-0.109	5.667	5.656	-0.010	3.397	3.336
I	3.049	2.951	-0.098	2.897	2.794	-0.103	2.707	2.601	-0.106	2.469	2.361	-0.108	2.412	2.304	-0.108	5.668	5.656	-0.012	3.408	3.348
J	4.235	4.201	-0.034	4.199	4.136	-0.063	4.155	4.072	-0.083	3.991	3.991	-0.000	4.093	3.991	-0.102	5.668	5.656	-0.012	4.325	4.374
K	4.471	4.453	-0.018	4.426	4.412	-0.014	4.391	4.385	-0.006	4.352	4.359	0.007	4.338	4.351	0.013	5.668	5.656	0.012	4.604	4.576
L	4.449	4.392	-0.057	4.390	4.324	-0.066	4.332	4.275	-0.057	4.255	4.202	-0.053	4.193	4.137	-0.056	5.668	5.656	-0.012	4.593	4.536
M	3.441	3.464	0.023	3.400	3.428	0.028	3.368	3.395	0.027	3.326	3.347	0.021	3.293	3.312	0.019	5.667	5.655	0.012	3.539	3.567
N	3.338	3.352	0.014	3.293	3.318	0.025	3.261	3.285	0.024	3.223	3.238	0.015	3.193	3.204	0.011	5.667	5.655	0.011	3.431	3.447
O	3.040	2.956	-0.084	2.896	2.848	-0.048	2.789	2.812	0.023	2.750	2.764	0.014	2.720	2.730	0.010	5.666	5.655	0.009	3.394	3.339
P	2.864	2.867	0.003	2.669	2.673	0.004	2.432	2.440	0.008	2.122	2.131	0.009	2.049	2.057	0.008	5.670	5.662	0.008	3.352	3.352
Q	2.912	2.918	0.006	2.714	2.720	0.006	2.470	2.478	0.008	2.149	2.158	0.009	2.075	2.083	0.008	5.714	5.701	0.008	3.402	3.404
R	2.924	2.930	0.006	2.725	2.732	0.007	2.479	2.487	0.008	2.156	2.165	0.009	2.082	2.090	0.008	5.728	5.714	0.008	3.414	3.416
S	2.925	2.931	0.006	2.726	2.732	0.006	2.479	2.488	0.009	2.156	2.166	0.010	2.083	2.090	0.007	5.732	5.719	0.007	3.416	3.418

Peak Water Surface Levels

7) Appendix 2 – Detailed model results