



Flood Mitigation Report

Flood Mitigation Adaptation for Painkalac Creek Estuary, Aireys Inlet

Surf Coast Shire

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ACKNOWLEDGEMENT OF COUNTRY

The Board and employees of Water Technology acknowledge and respect the Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of Country throughout Australia. We specifically acknowledge the Traditional Custodians of the land on which our offices reside and where we undertake our work.

We respect the knowledge, skills and lived experiences of Aboriginal and Torres Strait Islander Peoples, who we continue to learn from and collaborate with. We also extend our respect to all First Nations Peoples, their cultures and to their Elders, past and present.



Artwork by Maurice Goolagong 2023. This piece was commissioned by Water Technology and visualises the important connections we have to water, and the cultural significance of journeys taken by traditional custodians of our land to meeting places, where communities connect with each other around waterways.

The symbolism in the artwork includes:

- Seven circles representing each of the States and Territories in Australia where we do our work
- Blue dots between each circle representing the waterways that connect us
- The animals that rely on healthy waterways for their home
- Black and white dots representing all the different communities that we visit in our work
- Hands that are for the people we help on our journey



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1 INTRODUCTION

1.1 Overview

Water Technology has been commissioned by Surf Coast Shire (The Shire) to undertake the Flood Mitigation Adaptation for Painkalac Creek Estuary Study. The project objective is to develop an understanding of climate impacts on the flood risk within the Painkalac Estuary and the inundation and erosion hazards on the Aireys Inlet and Fairhaven open coastline.

This report deliverable (Flood Mitigation Report) is one of multiple key deliverables of the wider project. Each reporting stage is shown below:

- 01: Gap Analysis Memo
- 02: Erosion Hazard Report
- 03: Coastal Inundation Hazard Assessment Report
- 04: Catchment Hydrology Report
- **05: Flood Mitigation Report – (this report)**
- 06: Adaptation Pathway Assessment

1.2 Study Area

The location of the Painkalac Creek catchment and significant nearby waterways are shown in Figure 1.1.

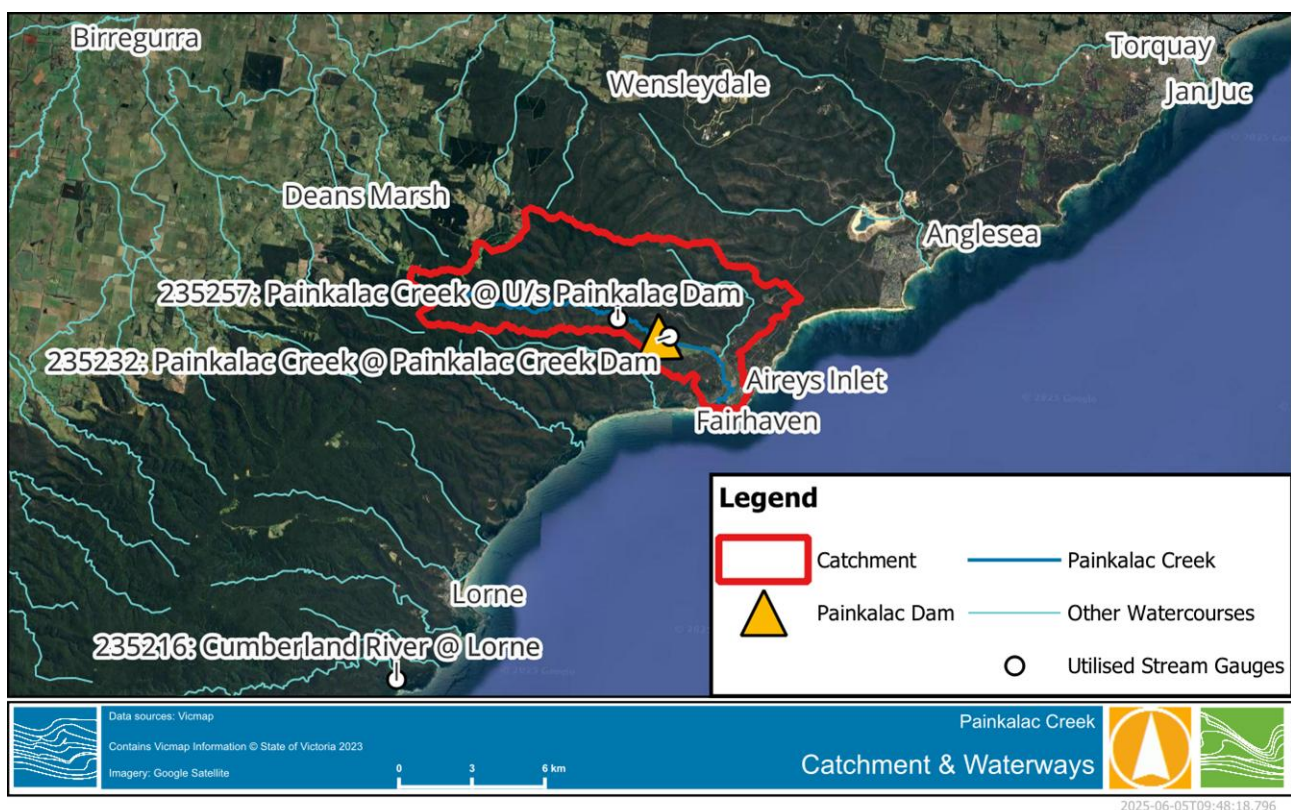


Figure 1.1 Painkalac Creek catchment and surrounding waterways



1.3 Study objective

The objective of this report is to present a prefeasibility assessment of flood mitigation options. A broad range of options were developed in collaboration with the Shire, CMA, community, and other stakeholders. These options were reviewed, from which those considered suitable for further investigation were selected for hydraulic modelling. A total of ten mitigation options were assessed. For options that produced appreciable changes in flood levels, a flood damage assessment was undertaken to quantify and compare the associated monetary impacts.

1.4 Prefeasibility mitigation options

The mitigation options assessed are presented in Table 1.1.

Table 1.1 Mitigation options

Mitigation options	Modelling approach	Model	Annual Ave. Damages (AAD) and benefit-cost assessment
Water sensitive urban design (WSUD)	Yes (one event for sensitivity)	Hydrodynamic estuary model (MIKE 21 FM)	No
Dam storage at 50% capacity	Yes (one event for sensitivity)	Hydrologic model (Rorb)	No
Retarding basin	Yes (all 6 AEP events)	Hydrodynamic estuary model (MIKE 21 FM)	Yes
Rewilding of floodplain	Yes (all 6 AEP events)	Hydrodynamic estuary model (MIKE 21 FM)	Yes
Levee	Yes (all 6 AEP events)	Hydrodynamic estuary model (MIKE 21 FM)	Yes
Raise the Great Ocean Road and add culverts	Yes (all 6 AEP events)	Hydrodynamic estuary model (MIKE 21 FM)	Yes
Berm opening (present management practice)	Yes (all 6 AEP events)	Hydrodynamic estuary model (MIKE 21 FM)	Yes
Berm height management (berm 'grooming')	Yes (all 6 AEP events)	Hydrodynamic estuary model (MIKE 21 FM)	Yes
Voluntary house purchase (Buy-back)	Yes	n/a	Yes
Retrofitting building materials	Yes	n/a	Yes



2 MITIGATION ASSESSMENT AND RESULTS

2.1 Overview

This section outlines the mitigation setups and the results of the modelled options. For each option, an overview, results, and remarks section are provided to summarise key findings and insights.

2.2 Water sensitive urban design (WSUD)

Overview

Water Sensitive Urban Design (WSUD) (including urban gardens) is an integrated approach to urban planning and design that manages stormwater sustainably, that can in certain settings reduce flood risk, improve water quality, and enhance liveability and ecological outcomes. WSUD can help to reduce flood risk by slowing, storing, and controlling stormwater runoff through measures such as rain gardens, swales, and detention basins, preventing peak flows from overwhelming drainage systems.

The effectiveness of implementing WSUD through Aireys Inlet residential zones to reduce the flood impact on the Painkalac Estuary was investigated in the estuary model. The investigation consisted of two scenarios, as per:

- WSUD Scenario A: present-day climate conditions with a 1% AEP catchment flood event (berm closed)
- WSUD Scenario B: present-day climate conditions with a 1% AEP catchment flood event (berm closed) – flow from residential zones **REMOVED**

The difference between the two scenarios is that in Scenario B, rainfall over the 'Residential' and 'Low-Density Residential' catchment segments (Figure 2.1) was excluded from the estuary model. This represents a scenario in which rainfall in these areas is assumed to be fully captured and retained by WSUD systems.

Results

Model result comparison of maximum surface elevation along the length the estuary channel for the two scenarios is presented in Figure 2.2. Removing the contribution of rainfall from over the residential segments reduced the floodwater levels by 0.03 m on average along the estuary (~1% reduction of the flood level).

The maximum extent of the floodwater with and without the contribution of input from the township is presented in Figure 2.3.

It should be noted that this scenario assumes WSUD systems capture 100% of rainfall in the residential zones; in reality, such systems are unlikely to be fully effective, so the resulting reduction in flood levels would likely be less than 0.03 m.

Remarks

WSUD measures are effective for water quality improvement and minor runoff attenuation, but they provide negligible flood mitigation benefit during large, short-duration storm events typical of flashy estuaries. Their storage capacity is generally insufficient relative to flood volumes.

This is especially true for the Painkalac catchment, where the residential area is small relative to the total catchment area, limiting the potential flood mitigation provided by WSUD measures.

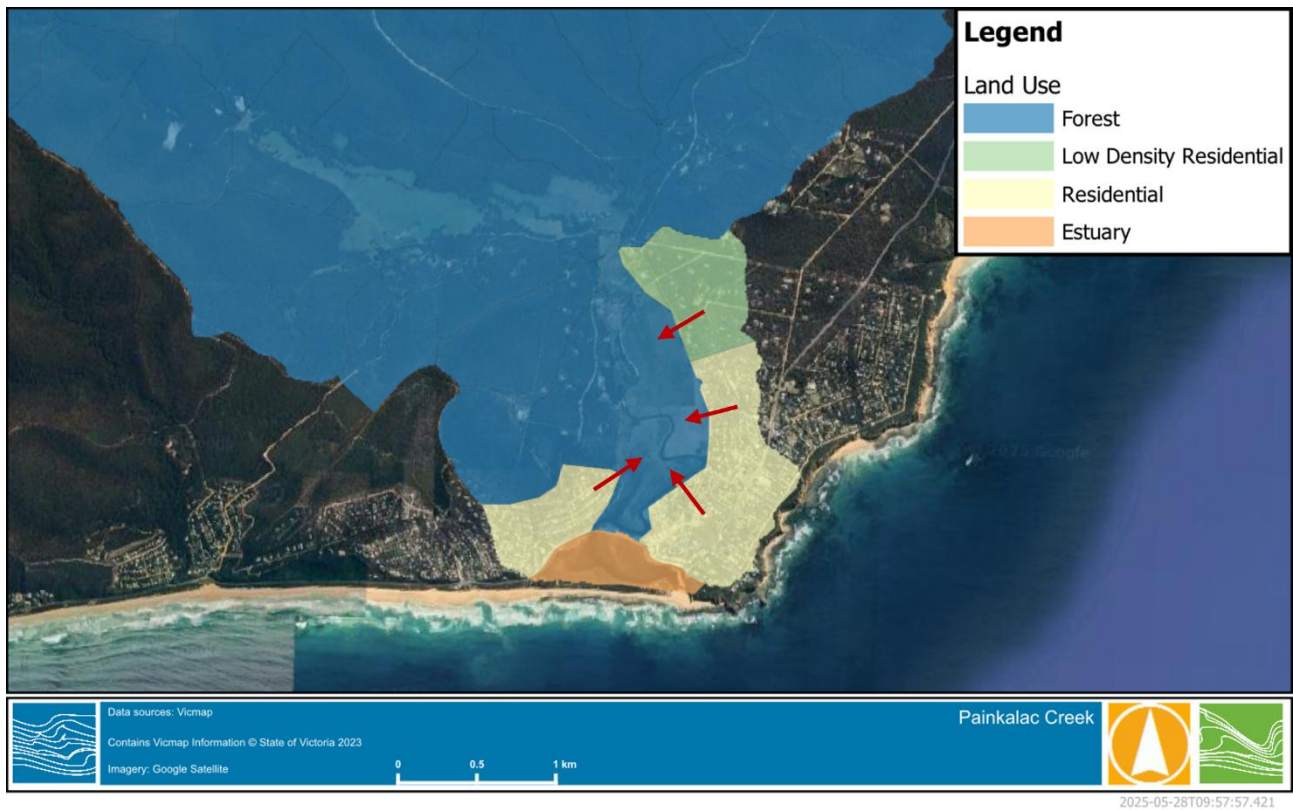


Figure 2.1 Contribution of rainfall runoff from Aireys inlet residential and low-density residential zones (red arrows)

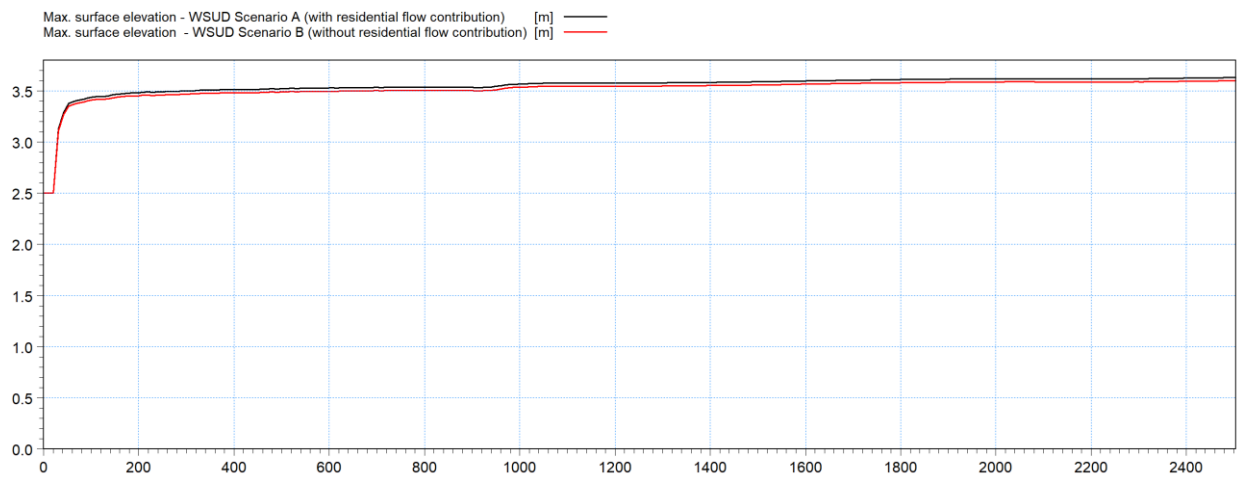


Figure 2.2 Maximum water level along the estuary channel centre line for WSUD scenario A and B

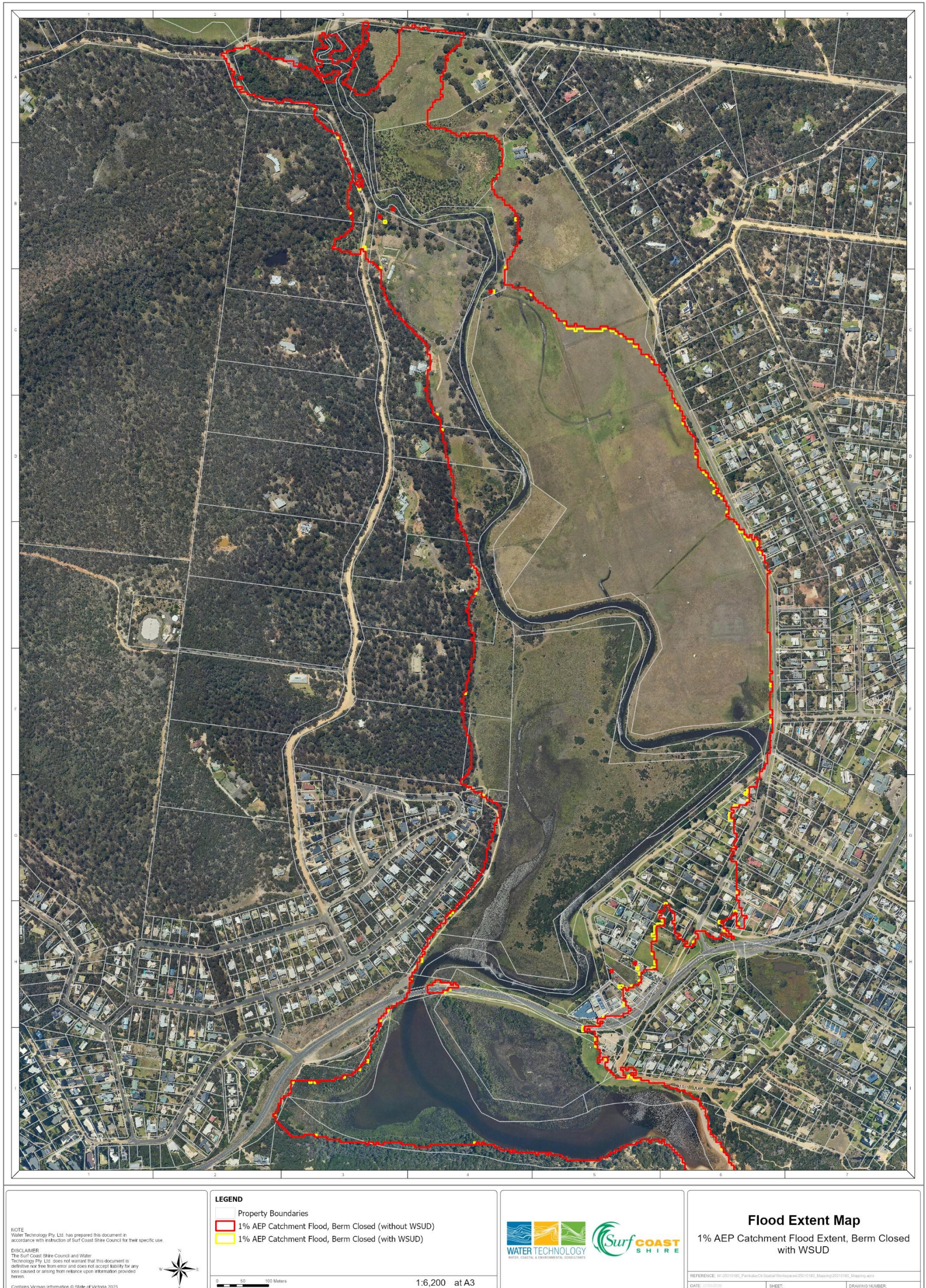


Figure 2.3 1% AEP catchment flood with berm closed. Floodwater extents without the WSUD (red) and with the WSUD (yellow)



2.3 Dam storage at 50% capacity

Overview

The impact of leaving the storage at 50% full, i.e. the starting level of the storage set to 27.2m AHD (halfway between the empty level of 23.7 m AHD and spillway level of 30.7m AHD) was tested for the SSP5-8.5 2030 climatic conditions rainfall events.

Results

Peak flow rates in Painkalac Creek at Old Coach Road under the dam starting full and dam starting halfway scenarios are presented in Table 2.1 below. The results show that the dam starting level has a reasonable impact in a minor 20% AEP event, however the available volume is taken up in larger events with a 10% AEP showing only a 7% decrease in peak flow at the Old Coach Road crossing, reducing to just 1% difference in the 1% AEP event.

Table 2.1 Peak flows in Painkalac Creek at Old Coach Road, Painkalac Dam full vs halfway

AEP	Peak flow, dam initially full (m ³ /s)	Peak flow, dam Initially halfway (m ³ /s)	Difference (m ³ /s)	% Difference
20%	32.97	24.14	8.83	27%
10%	47.29	44.10	3.20	7%
5%	63.78	59.24	4.54	7%
2%	91.40	89.27	2.13	2%
1%	108.72	107.71	1.01	1%
1 in 200 yr	129.05	128.37	0.68	1%

Remarks

Keeping the dam at 50% capacity provides only limited flood mitigation benefits. While it can modestly reduce peak flows in minor events, its effect is minimal for larger, more extreme events, with reductions in peak flow dropping to just 1% during a 1% AEP event.

Maintaining dam airspace can reduce peak downstream flows for some events. However, in flashy catchments, flood peaks may exceed dam attenuation capacity, and effectiveness depends on timing, operational control, and rainfall quantity. It is not a reliable standalone flood mitigation measure.

2.4 Retarding basin

Overview

Retarding basins temporarily store stormwater runoff during heavy rainfall and release it at a controlled rate to prevent flooding. They do not retain water permanently, instead focusing on peak flow reduction and protecting waterways from sudden surges.

The proposed retarding basin perimeter is shown in Figure 2.4. The basin floor is set at 0 m AHD, approximately 2 m lower than the surrounding ground level. A saddle at 1.8 m AHD was established at the southern connection to the estuary system to control the threshold at which floodwaters enter the basin. This level was selected to be 0.4 m below the floor of the lowest flood-prone houses along River Reserve Road (~2.2 m), allowing the basin to reduce flood levels in the most vulnerable part of the community once saddle height threshold is exceeded.



The effectiveness of the retarding basin was tested across several scenarios. To test the effectiveness of the basin under different flood magnitudes, the 1 % and 10 % catchment events were tested. To test the effectiveness of the basin under different berm configurations, both berm open and berm closed scenarios were tested. All scenarios were tested with present day conditions.

Results

The scenario setup and results are presented in Table 2.1. Note: to capture the full capacity of the basin in the modelling, the initial water level was set to -0.1 m AHD for all runs. The maximum flood extent for the 1% AEP event is presented in Figure 2.5.

The results indicate that the retarding basin has a limited effect on reducing water levels across the selected scenarios.

Table 2.2 Retarding basin flood mitigation test results

Basin Scenario	Catchment AEP	Storm tide	Berm configuration	Avg. reduction in max. flood level (m)	Avg. reduction in max. flood level (as a %)
Basin Scenario A	10% AEP	No storm tide	Closed	0.04	1%
Basin Scenario B	1% AEP	No storm tide	Closed	0.01	<0.1%
Basin Scenario C	1% AEP	With storm tide (1% AEP)	Open	<0.01	<0.1%

Remarks

Retarding basins can attenuate small to moderate flows if appropriately sized. In flashy estuaries, such as the Painkalac Estuary, the storage volumes required to materially reduce flood peaks are often impractically large. There is insufficient available space to construct a retarding basin of the required scale in the Painkalac system.

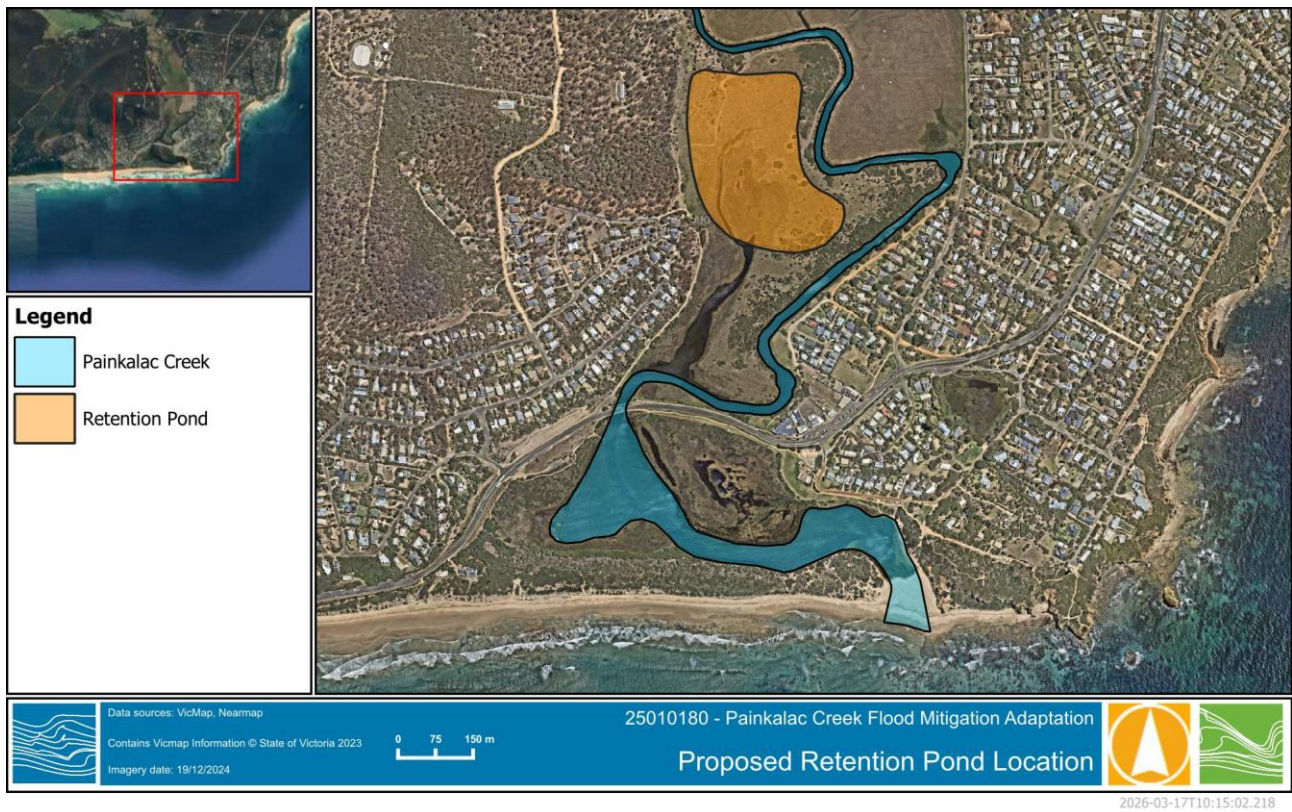


Figure 2.4 Proposed retarding basin location

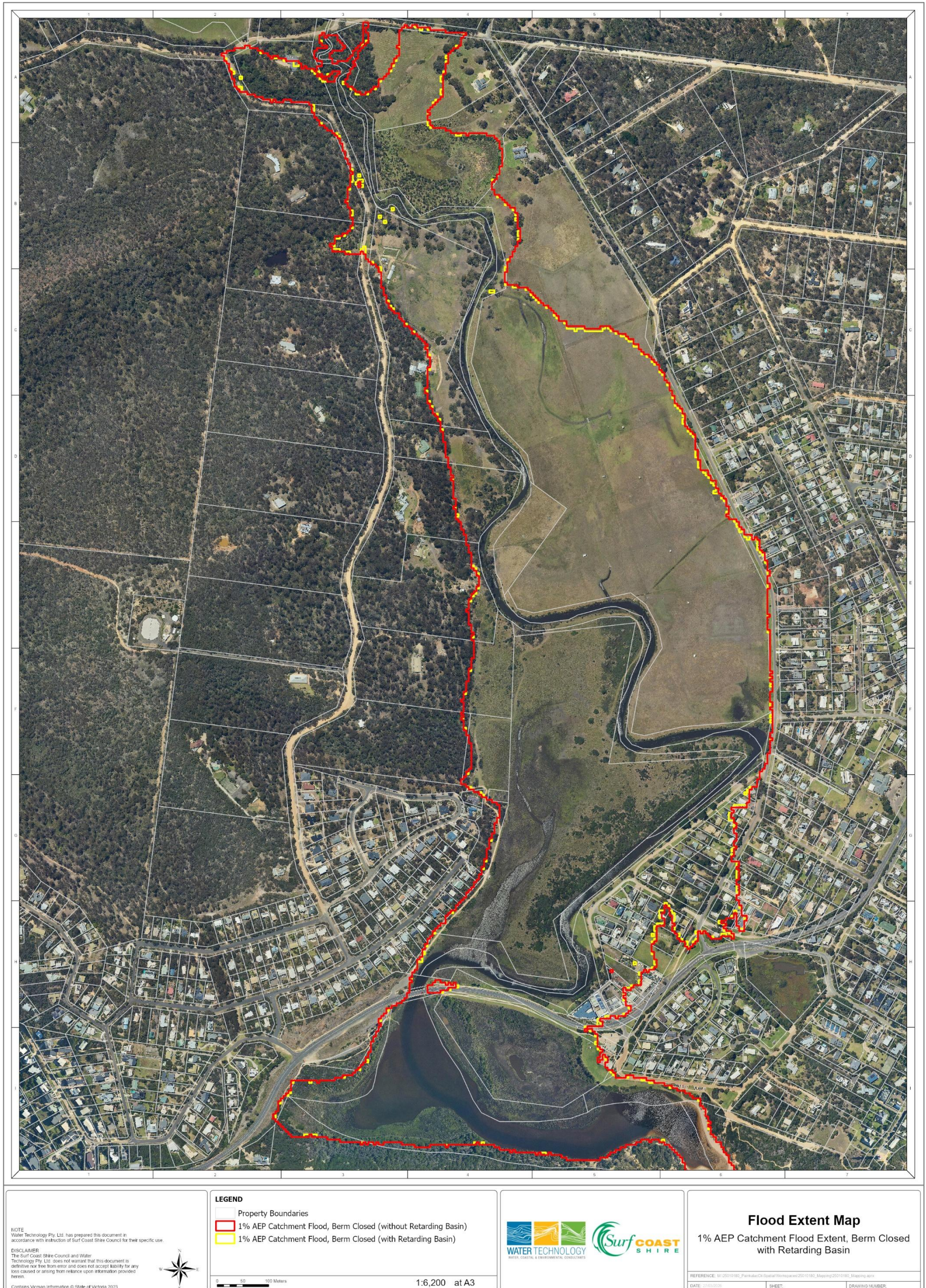


Figure 2.5 1% AEP catchment flood with berm closed. Floodwater extents without the retarding basin (red) and with the retarding basin (yellow)

2.5 Rewilding

Overview

Rewilding can reduce flood risk by restoring natural processes such as vegetation cover, wetlands, and floodplain connectivity, which increase infiltration, slow runoff, and enhance temporary water storage. These measures are most effective in upper and mid-catchments with available space and permeable soils, where they can attenuate peak flows and delay flood timing. However, their effectiveness is limited in low-lying estuaries constrained by downstream controls (e.g. narrow entrances or high tailwater levels), where flood behaviour is dominated by hydraulic bottlenecks rather than localised catchment runoff processes.

The area of proposed rewilding is presented in Figure 2.6. In the model a Manning's M roughness value of 13 (equivalent Manning's n of ~ 0.08) was applied across this area to define and emulate the increase in bed resistance attributed to the increase in vegetation coverage and type. In addition, all rainfall flow input from the adjacent township was excluded from the model, to reflect 100% effectiveness of the rewilding area on retarding the flow from the eastern township from entering the estuary system.

Results

The maximum flood extent for the 1% AEP event is presented in Figure 2.7. Negligible differences in the flood extent was observed in response to the rewilding of the floodplain.

Remark

Rewilding of the floodplain, while effective in increasing infiltration and slowing runoff in suitable catchments, produced negligible reductions in flood extent for the 1% AEP event in this estuary in context.

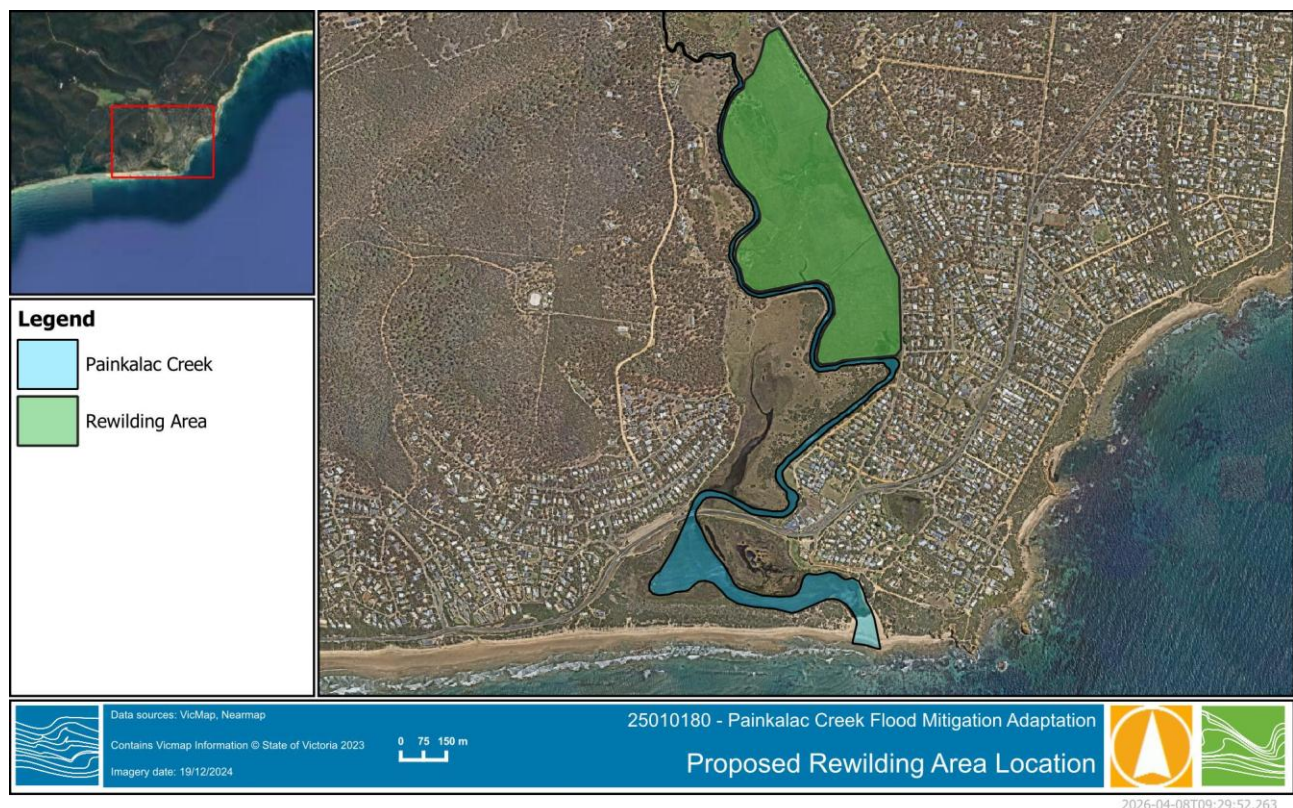


Figure 2.6 Area of proposed rewilding

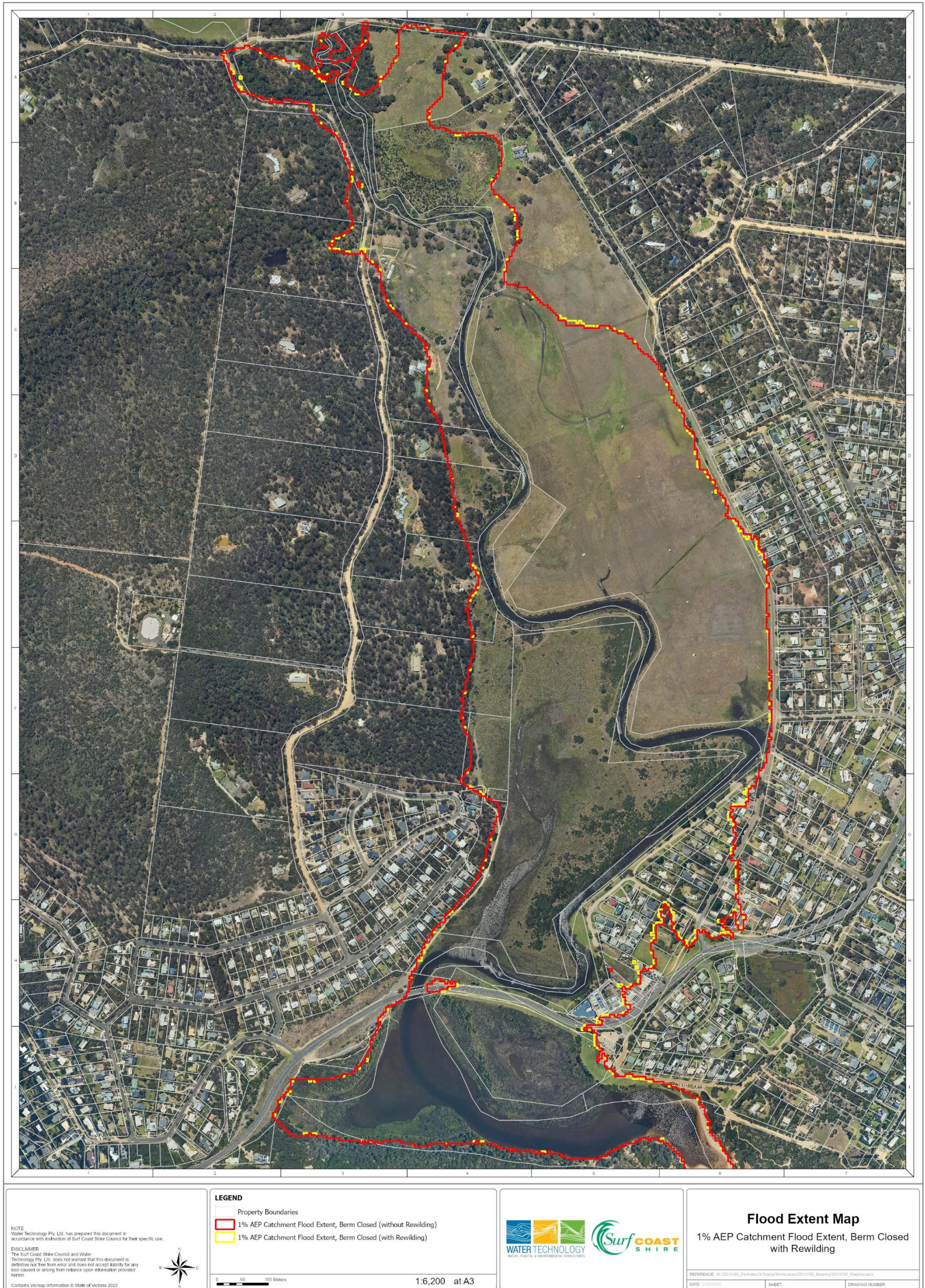


Figure 2.7 1% AEP catchment flood with berm closed. Floodwater extents without the rewilding (red) and with rewilding (yellow)



2.6 Levee

Overview

Levees are engineered embankments used to contain floodwaters and prevent inundation of adjacent land by increasing the effective capacity of rivers, estuaries, or coastlines. They are typically applied in low-lying, developed floodplains where protection of existing assets is required and retreat or relocation is not feasible. Key advantages include providing high levels of protection over large areas, clear and predictable levels of flood protection, and the ability to be raised or upgraded as flood risk evolves.

The levee crest was set to 3.9 m AHD, designed to exceed the 1% AEP catchment maximum flood level by 0.3 m of freeboard. Figure 2.8 shows the levee structure alignment tested in the model. A road closure floodgate is planned at the intersection of the levee and the Great Ocean Road. The effectiveness of the levee was tested with present day conditions, a closed berm and a 1% AEP catchment flood.

Results

The addition of the levee caused a negligible difference in maximum water level across the estuary, therefore flood conditions elsewhere throughout the estuary were not exacerbated. The reduction in flood extent attributed to the levee is presented in Figure 2.9 and is largely observed within the township to the east of the levee.

Remarks

The levee option effectively reduces flood risk across the township to the east of the levee and does not exacerbate flood risk in other areas of the estuary. Likely due to the steep topography along the western side of the estuary aiding to confine the floodwater. With a crest height ranging between 1.5 m and 2 m above the ground level along River Reserve Road, the levee may impede the view of the estuary at ground level at low-lying areas, potentially impacting the amenity of the area.



Figure 2.8 Proposed levee location

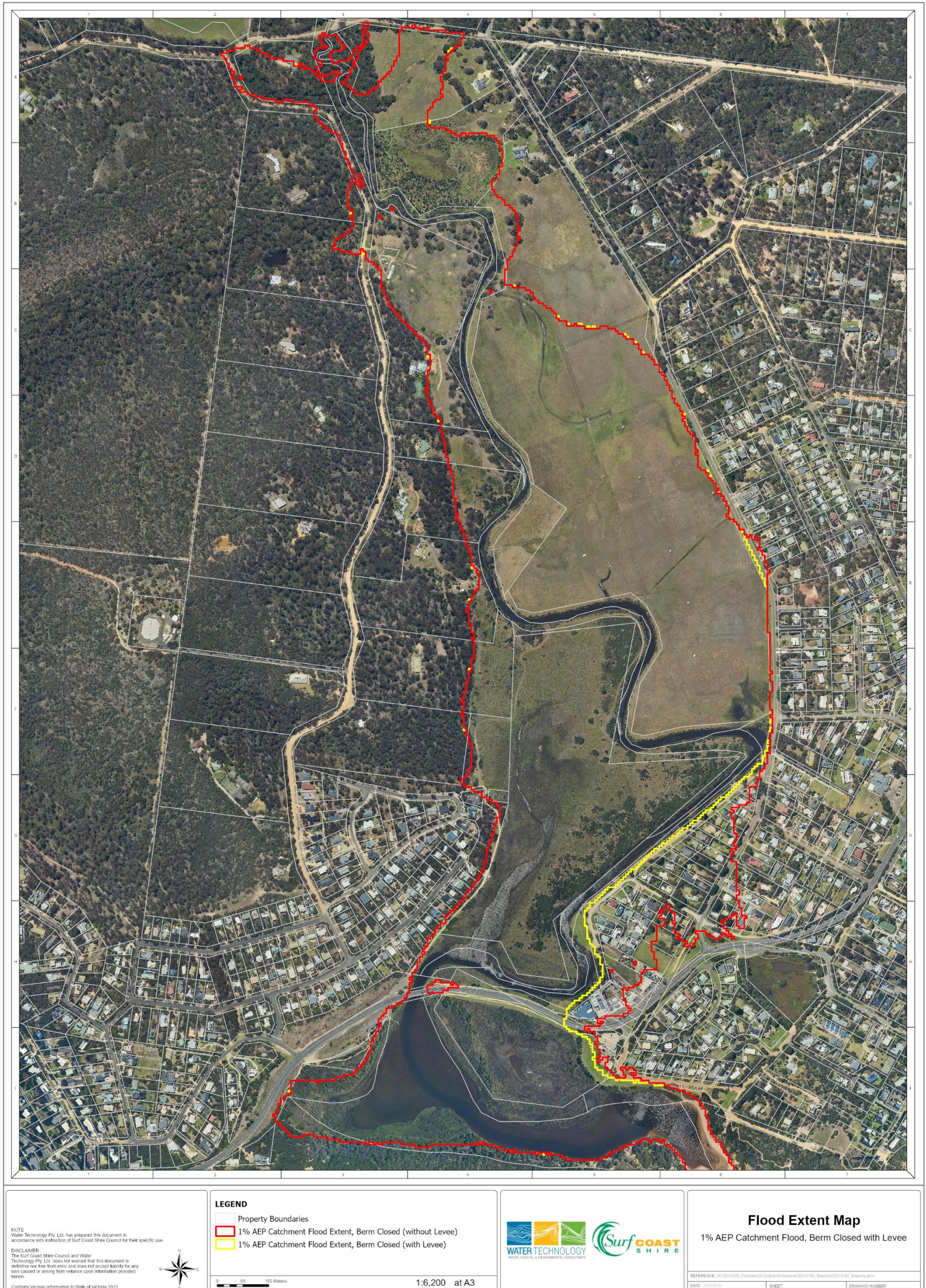


Figure 2.9 1% AEP catchment flood with berm closed. Floodwater extents without the levee (red) and with the levee (yellow)



2.7 Berm height management

Overview

Berm height management can influence estuary water levels by controlling outlet flow capacity and therefore estuary water levels. Maintaining the berm at a height below the level of the lowest properties can reduce flood risk.

The scenarios tested under berm height management are presented in Table 2.3.

Table 2.3 Berm height management scenarios

Horizon	Berm status	Berm height (m)
Present day	Average closed condition	2.5
Present day	Lowered / lower than storm tide level, however, storm tide level < 2.2 m (Note: lowest lying properties flood @ 2.2 m)	2

Results

The reduction in flood extent resulting from lowering the berm is shown in Figure 2.10. A moderate reduction in flood extent is observed attributed to the 0.5 m berm height reduction. However, in contrast, the berm open scenario allows more floodwater conveyance, resulting in considerably reduced flood extent, as illustrated in Figure 2.14 (red line).

Remark

Berm height management has a moderate effect in reducing flood extents. Lowering the berm by 0.5 m provides a modest reduction in floodwaters, but it is not as effective as the open-mouth scenario, which is substantially more effective at mitigating flood impacts.

A broader benefit of this option is that sand removed from the berm during the lowering process would be available for coastal protection elsewhere along the coast. For example, sediment could be back-passed along the beach to support dune protection in front of the Fairhaven Surf Club. This approach aligns with Sections 13.7–13.10 of the Marine and Coastal Policy (2020) relating to co-investment arrangements and supports cost-sharing for the operation among beneficiaries.

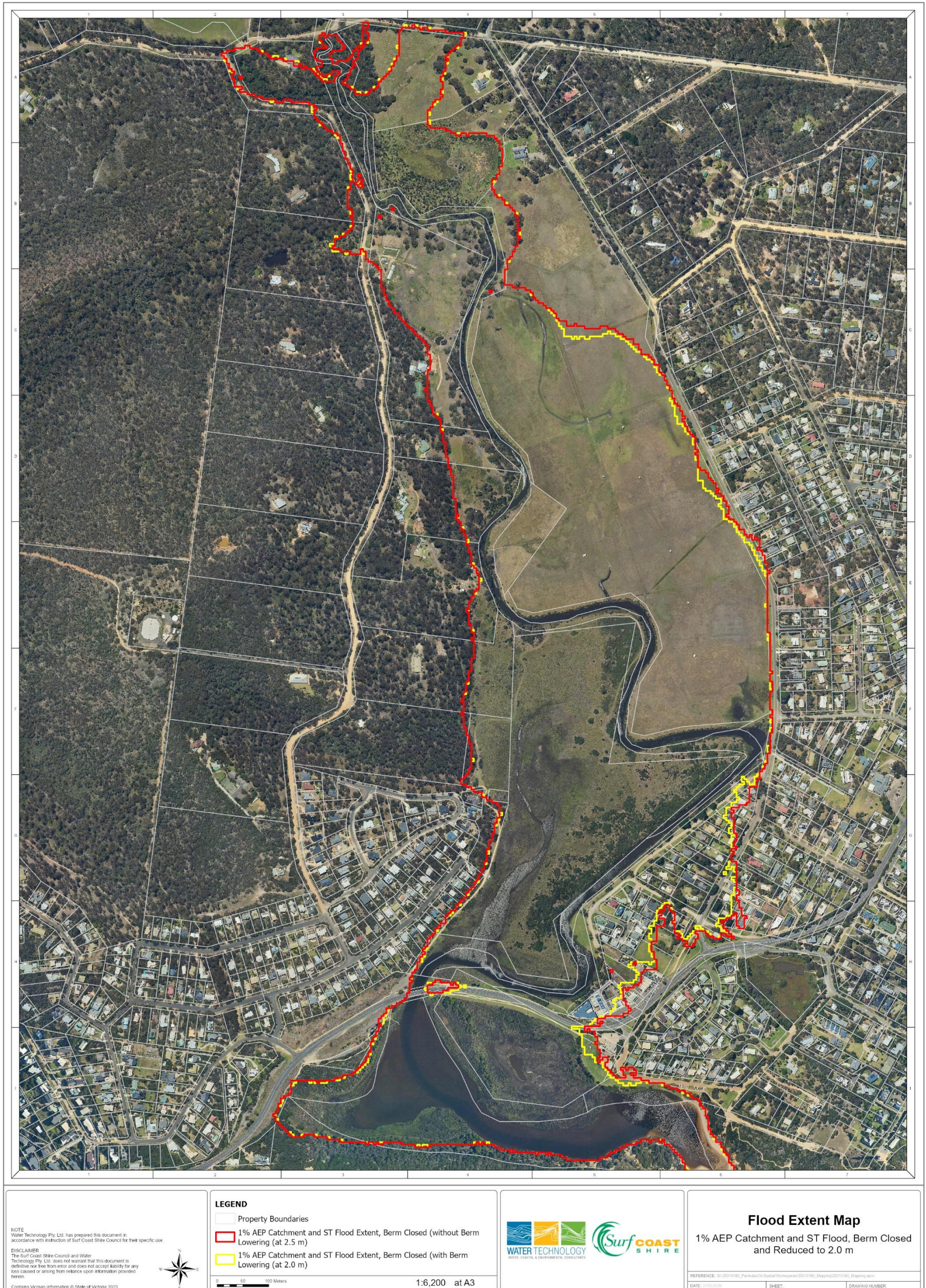


Figure 2.10 1% AEP catchment flood with berm closed. Floodwater extents without berm lowering (red) and with berm lowering to 2 m (yellow)



2.8 Raise GOR bridge and add culverts

Overview

Raising the road and introducing additional conveyance capacity via culverts would reduce hydraulic constriction, currently occurring at the bridge where the channel narrows, thereby improving flood conveyance and lowering upstream water levels during flood events. This approach is considered one of the more effective structural measures for flashy estuaries, provided culverts are adequately sized, aligned with flow paths, and resilient to debris blockage.

The proposed location to raise the road and install culverts is presented in Figure 2.12. The proposed length of the raising of the road and the addition of culverts is ~270 m. The lowest point of the road at present is 2.9 m AHD. The road was raised to 4.2 m AHD for the assessment.

Table 2.4 Culvert and road level setup

Item	Configuration
No. of culverts	91
Culvert width (internal / external)	2.64 m / 3 m
Culvert height (internal / external)	1.92 m / 2.1 m
Culvert base level	2 m AHD
Freeboard allowance above present day 1% AEP level	0.3 m
Assumed road surface thickness	0.1 m
Raised road surface level	4.2 m AHD

Results

Raising the road and installing culverts does not significantly reduce flood levels for the 1% AEP catchment event under closed berm conditions, as shown in Figure 2.13. This is primarily due to the hydraulic control imposed by the narrow creek entrance in combination with the closed berm, which restricts floodwater conveyance. As a result, the entrance governs estuary hydraulics, and improvements to internal conveyance (e.g. additional culverts at the road) have limited effectiveness.

To test the sensitivity of the entrance control, the same culvert configuration was modelled under open berm conditions for the 1% AEP catchment event combined with a 1% AEP storm tide. The results demonstrate enhanced conveyance through the entrance when the berm is open (Figure 2.11; green vs black line). The results also highlight a hydraulic constriction at the bridge approximately 1,000 m upstream, evidenced by the sharp rise in water levels (black line), while improved conveyance through the culverts reduces peak flood levels upstream of the bridge (red vs black line).

The extent of reduced flood impacts resulting from the raised road and culverts is shown in Figure 2.14.

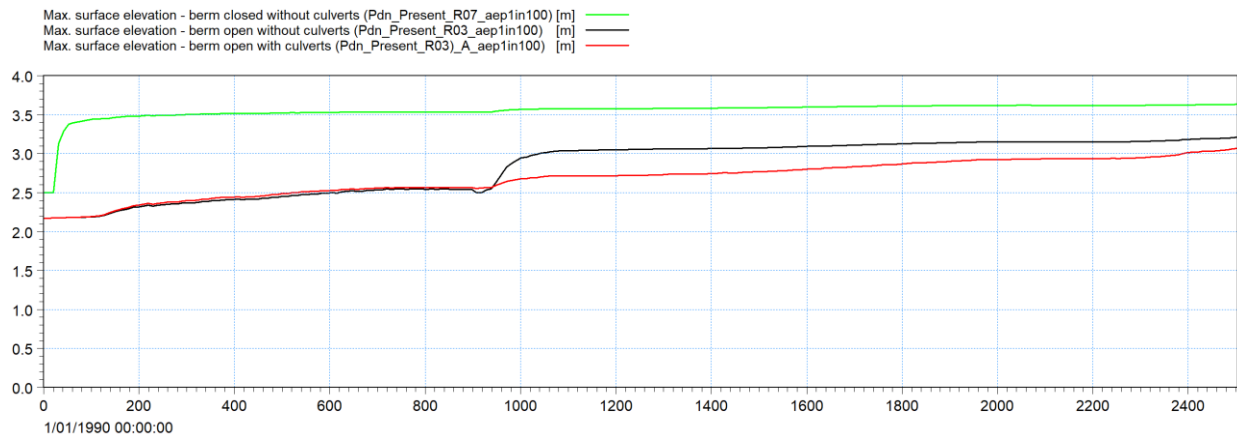


Figure 2.11 Maximum water level along the estuary channel centre line for the berm closed without culverts (green), berm open without culverts (black) and berm open with culverts (red)

Remarks

The results indicate that under closed berm conditions, the estuary entrance controls flood behaviour, limiting the effectiveness of increased conveyance at the road crossing. While opening the berm improves overall conveyance, the culverts help alleviate the hydraulic constriction at the bridge, thus further reducing upstream flood levels and lowering flood impacts in the low-lying areas of the town.

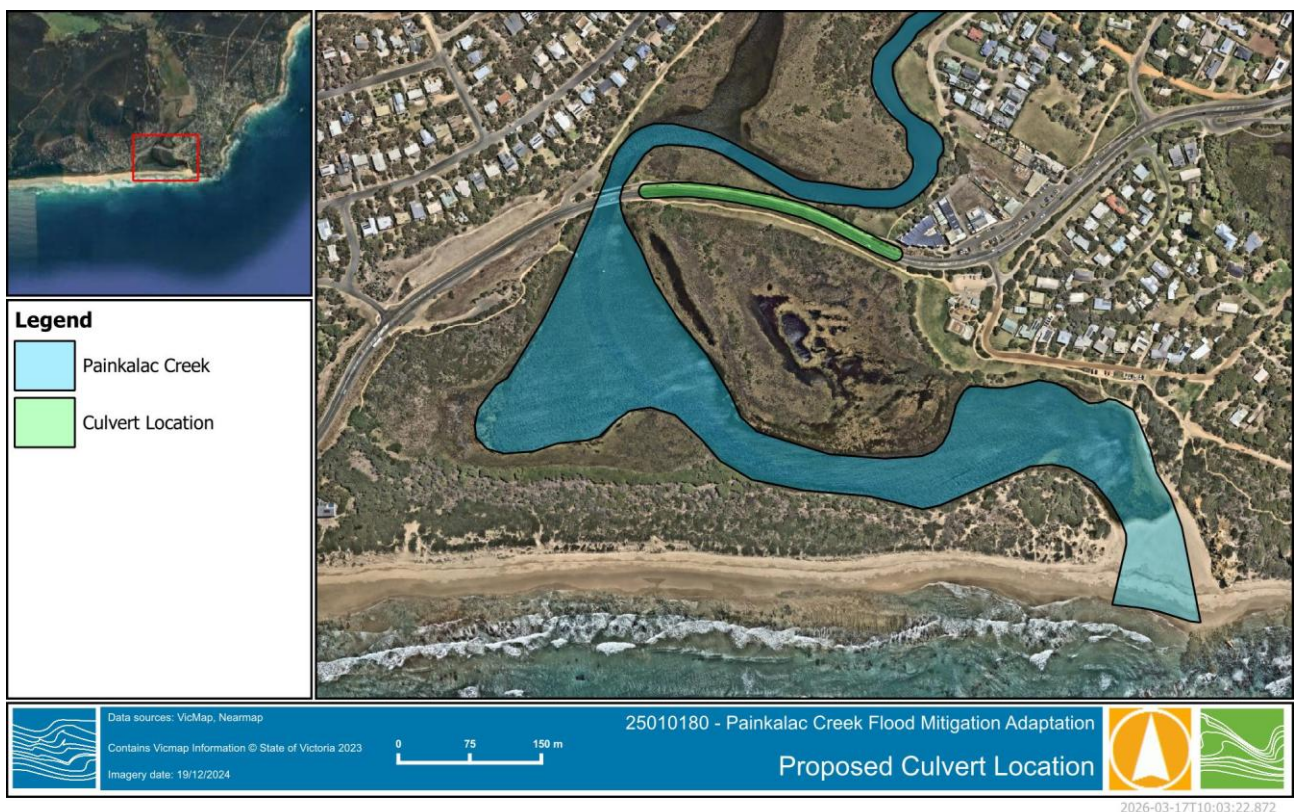


Figure 2.12 Proposed culvert location and raising of the Great Ocean Road

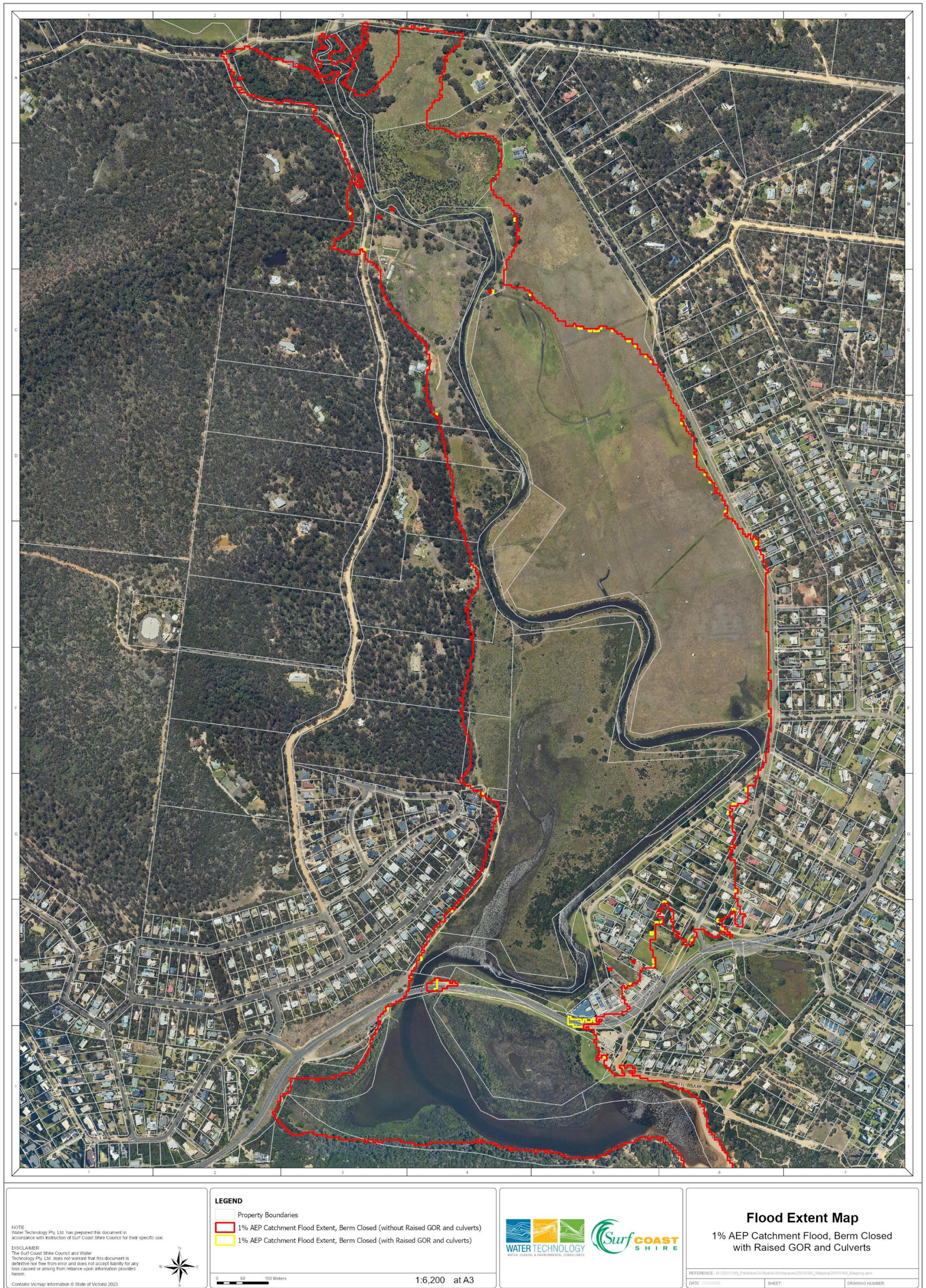


Figure 2.13 1%AEP catchment flood with berm closed. Floodwater extents without raised road and culverts (red) and with raised road and culverts (yellow)

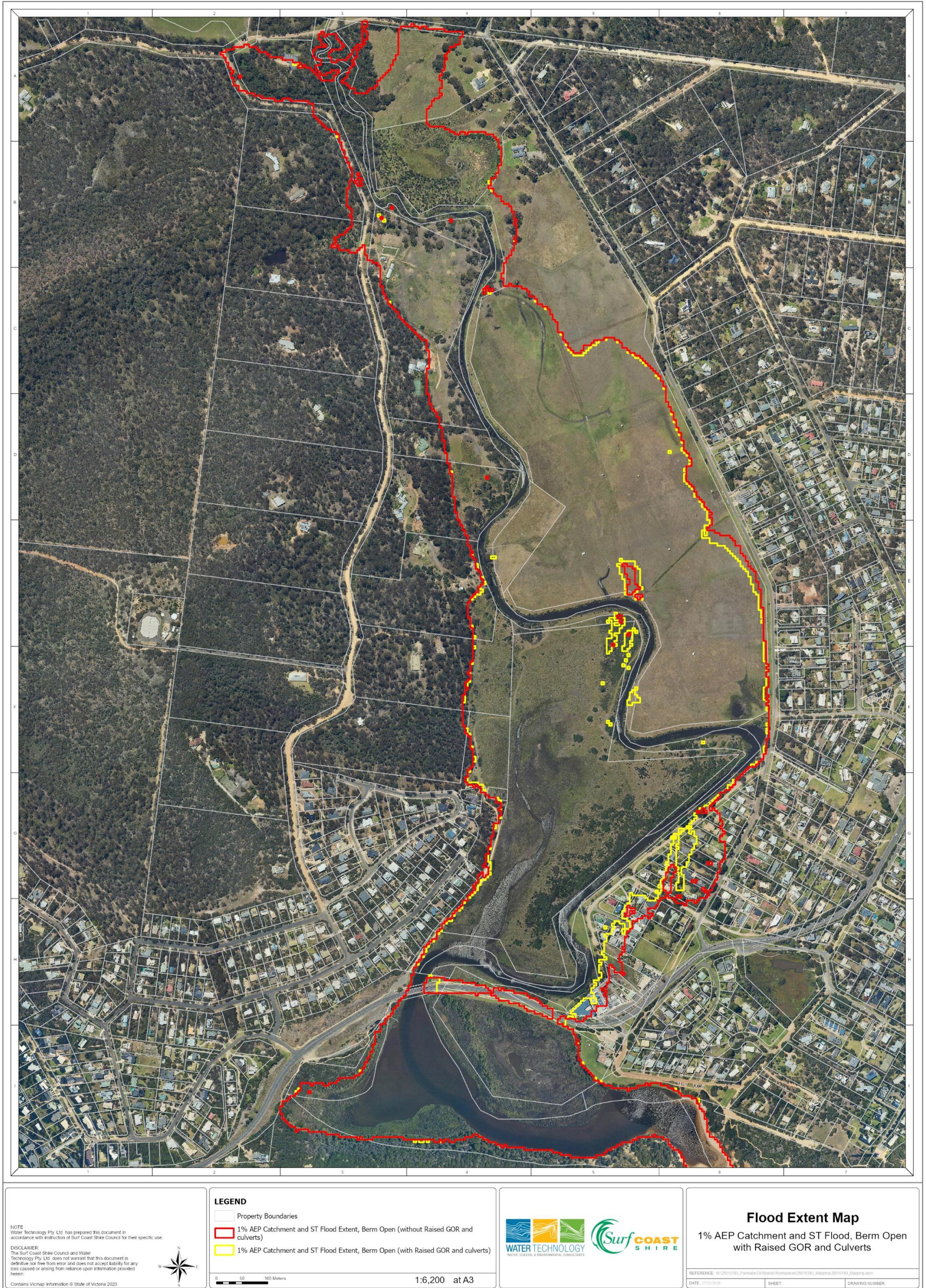


Figure 2.14 1%AEP catchment and ST flood with berm open. Floodwater extents without raised road and culverts (red) and with raised road and culverts (yellow)



2.9 Voluntary house purchase (buy-back)

Overview

Voluntary house purchase (buy-back) schemes involve government acquisition of flood-prone properties from willing homeowners, typically targeting those at highest risk and least suitable for other mitigation measures. Purchased homes are demolished and the land is re-zoned to non-habitable uses such as open space, permanently removing exposure to future flooding. While effective in eliminating long-term risk, these programs are costly and generally applied selectively where other flood mitigation options are not viable. The approach does not reduce flood levels but instead it removes exposure of assets entirely.

Results

The voluntary house purchase assessment was carried out on the berm closed 1% AEP catchment flood event. The results of the voluntary house purchase scenario are presented in Section 3 and Section 4.

2.10 Retrofitting building materials

Overview

Retrofitting building materials involves upgrading existing homes in flood-prone areas with flood-resilient design and materials to reduce damage and improve recovery following inundation. Measures such as water-resistant finishes, raised services, and modified wall and floor systems are most effective in lower hazard flood areas where structural damage risk is limited (Queensland Reconstruction Authority, 2019). While this approach does not remove exposure to flooding, it reduces economic losses and enables faster reoccupation of homes after flood events.

Results

The retrofitting building materials assessment was carried out on the berm closed 1% AEP catchment flood event. The results of the retrofitting building materials scenario are presented in Section 3 and Section 4.



3 DAMAGES ASSESSMENT

A flood damage assessment was undertaken for the selected options for testing. The flood damage assessment determined the monetary flood damage for the range of modelled present day design events (i.e. 20%, 10%, 5%, 2%, 1%, 0.5% AEP events).

Model results for all mapped flood events were processed to calculate the number and the locations of properties and roads affected. These included properties inundated above floor and properties which were not impacted but the grounds of the property were, and the lengths of flood affected roads. It should be noted that only sealed roads were assessed due to the availability of associated costs for flood damages.

Annual averaged flood damages (AAD) were calculated and summed for each property and road utilising the damage curves in Table 3-1 below.

Table 3.1 Damages curves utilised in assessment

Damage Category	Damage vs Depth Curve
Residential	Stage damage curves based on NSW Office of Environment and Heritage 2007 methodology ¹ (factored up to 2025 CPI)
Commercial	Stage damage curves based on ANUFLOOD 1992 methodology (increased by 60% as per RAM 2000 methodology ² , and factored up to 2025 CPI)

AAD values for the **baseline** conditions are provided in Table 3.2. An approximate tenfold reduction in AAD attributed to an open berm scenario compared to a closed berm scenario.

AAD values for the mitigation options are presented in

Table 3.3. Further assessment of the AAD values and the reduction of AAD values is explored in Section 4.

Table 3.2 AAD costs for 'baseline' present day open/closed berm conditions

Model Scenario 'Run number' (as per Coastal Inundation Hazard Assessment Report)	Catchment Flooding	Storm Tide	Berm	AAD
(Present day) 07	1% AEP	No storm tide	Closed	\$273,554
(Present day) 03	1% AEP	1% AEP	Open	\$28,210

¹ NSW Office of Environment and Heritage (2007) Floodplain Risk Management Guidelines: Residential Flood Damages

² NSW Office of Environment and Heritage (2007) Floodplain Risk Management Guidelines: Residential Flood Damages



Table 3.3 AAD costs for the options

Mitigation Option	AAD
Retarding basin	\$216,177
Rewilding of floodplain	\$222,756
Levee	\$10,535
Raise GOR with culverts (Berm Closed)	\$252,466
Berm opening (present management practice)	\$28,210
Berm height management (berm 'grooming')	\$105,321
Voluntary house purchase (Buy-back)	\$21,091
Retrofitting building materials	\$112,896



4 BENEFIT-COST ASSESSMENT

4.1 Results

The benefit-cost (B-C) assessment builds on the preceding flood modelling and AAD analysis by quantifying the economic effectiveness of the proposed mitigation options. The flood modelling defines the hazard and extent of inundation, while the AAD analysis translates these impacts into monetary damages across a range of flood events. The reduction in AAD achieved under each mitigation scenario represents the economic benefit, which is then compared against the implementation cost (i.e. construction, home buy-back cost, berm excavation works etc.) to determine the overall B-C ratio and inform the relative viability of each option.

The B-C for each option is presented in Table 4.1.

Table 4.1 Benefit-cost results

Mitigation Option	Reduction in AAD (Benefit) ³	Cost / y (assuming a 50-y design duration)	Benefit-Cost (B-C) ratio
Retarding basin	\$14,834	\$262,000	0.06
Rewilding of floodplain	\$8,254	\$8,600	0.96
Levee	\$263,019	\$134,000	1.96
Raise GOR with culverts	\$21,088	\$430,000	0.05
Berm opening (present management practice)	\$245,344	\$10,000 ⁴	24.53
Berm height management (berm 'grooming')	\$169,020	\$24,000 ⁵	7.04
Voluntary house purchase (Buy-back)	\$252,463	\$1,218,000	0.21
Retrofitting building materials	\$160,658	\$59,211	2.71

A detailed breakdown of the cost estimates is included in the bill of quantities, in Appendix B.

4.2 Limitations and assumptions

Limitations and assumptions applied in the assessment are provided below.

Costs

- Costs presented are upfront construction costs only; on-going operational and maintenance costs are excluded.
- Environmental costs and benefits have not been monetised in this assessment.
- Rates used for cost estimates were derived from a range of industry sources of varying accuracy. To ensure conservativeness, rates have been adjusted to reflect CPI increases, observed recent price

³ Both the baseline and production model simulations for the **retarding basin** and **rewilding** options required a reduced initial water level to represent the basins as 'dry' prior to flooding. This approach allowed effective testing of the siphoning of floodwaters from the creek system into the basins.

⁴ The cost assumes a present-day estimate of \$2,500 per berm opening (Surf Coast Shire), with four openings budgeted annually.

⁵ The cost is based on a present-day estimate of \$6,000 per berm management operation, covering a 20-25 m wide corridor with 300 m³ of sand moved to Fairhaven Surf Club using a Moxi truck, excavator, and bobcat for a 10-hour day at \$200/hr each, with four operations budgeted annually.



escalation, and anticipated near-term increases driven by global fuel cost pressures, which construction industry bodies have identified as imminent.

Rewilding scenario

- The rewilding scenario does not include the cost to acquire the land. Including the land values further reduces the B-C ratio by more than half.
- The rewilding scenario does not include ongoing maintenance for bush fire hazard reduction and management.

Flood damage (AAD) assessment inputs

- Building locations and footprints were identified using an open-source GIS building footprint dataset.
- Buildings smaller than 50 m² were excluded and assumed to represent sheds or non-habitable structures.
- Vicmap planning zones were used to determine whether buildings were residential or commercial.
- For commercial buildings, business type was estimated using a high-level review of street-view imagery.
- Above-floor flood levels were estimated by assigning assumed floor levels based on LiDAR data (ground level at building location plus 300 mm).

Flood damage cost assumptions

- Residential flood damage costs were estimated using residential stage-damage curves from NSW OEH (2007), factored to 2026-dollar values using CPI.
- Residential damage curves include allowances for both direct (structural and internal) and indirect (e.g. clean-up) damage costs.
- Commercial flood damage costs were estimated using ANUFLOOD commercial stage-damage curves, increased by 60% and factored to 2026 using CPI.
- Commercial damage curves do not include indirect damage costs; therefore, an additional 30% was applied to account for indirect impacts.
- External property damage (where flood levels remain below floor level) is not captured in the damage curves; accordingly, an additional 10% was applied to overall damage costs.
- Road flood damage costs were estimated using a unit cost per linear kilometre for major and minor roads.

Benefit–Cost analysis assumptions

- For voluntary property buy-back, the assumed purchase cost of a residential dwelling in Aireys Inlet is \$1.45 million, based on the average sale price over the past 12 months (realestate.com.au).
- The reduction in AAD for buy-back scenarios was calculated as 110% of building AAD (to account for direct, indirect, and external damages), applied over a 50-year assessment period.
- For retrofitting flood-resilient materials, the assumed installation cost for residential dwellings is \$430/m².
- The reduction in AAD for retrofit scenarios was calculated as 70% of building AAD (representing internal damage reduction only), applied over a 50-year assessment period.

4.3 Discussion

The Benefit-Cost (B-C) assessment indicates a clear spread in the economic performance of the mitigation options, with only a subset demonstrating strong viability. Berm opening (present management practice) provides the highest economic return, with a B-C ratio of 24.5, driven by a substantial reduction in AAD at relatively low cost. Berm height management also performs strongly (B-C = 7.04), indicating that relatively



minor operational interventions at the estuary entrance can deliver considerable flood damage reduction benefits.

The retrofitting of building materials yields a favourable B-C ratio of 2.71. This option is potentially most viable when targeted to frequently flooded properties, but is less effective when applied across the entire flood-affected area, particularly in zones inundated only during those less frequent events.

The levee option shows a moderate B-C ratio of 1.96, reflecting a high level of protection and large reduction in damages, albeit with higher capital costs; however, it would introduce a significant visual barrier, potentially obstructing views of the estuary and altering the character and amenity of the area for residents.

The rewilding of the floodplain results in a B-C ratio of 0.96, indicating it is close to cost-neutral; however, its limited reduction in AAD reflects the limited effectiveness in reducing flood levels across the estuary (note: the B-C further reduced by more than half when factoring in the land acquisition cost). While rewilding may provide broader environmental and ecological benefits, its effectiveness as a flood mitigation measure in this context is limited.

In contrast, several options demonstrate low economic justification. the voluntary house purchase option has a low B-C ratio (0.21), reflecting the high cost of property acquisition compared to the relatively modest reduction in AAD achieved under the scenarios tested. Similarly, the retarding basin and raising the Great Ocean Road with culverts both result in very low B-C ratios (0.06 and 0.05, respectively), indicating that these measures provide minimal reduction in flood damages relative to their cost. This reflects their limited hydraulic effectiveness, as they do not address the primary control on flood behaviour, namely the berm at the estuary entrance, which acts as a hydraulic choke point governing water levels. As a result, improvements to upstream storage or conveyance have little influence on peak flood levels when the entrance remains constricted.

If active berm management is no longer undertaken, the retrofitting of building materials provides the strongest economic performance. The levee option provides the second strongest economic performance; however, its potential impacts on visual amenity and the character of the estuary frontage may limit its acceptability.

Overall, the results highlight that measures targeting the primary hydraulic control of the estuary (i.e. berm opening and berm management) deliver the greatest economic benefit, whereas options that either do not address the key flow constraint or involve high implementation costs are less economically efficient.



5 RECOMMENDATIONS

Recommendations to increase the accuracy and robustness of the assessment for further work are as follows:

- Increase the accuracy of flood damage cost estimates by:
 - Obtaining surveyed floor levels for each building
 - Obtaining detailed information on building types and construction materials
 - Gathering specific data on commercial building uses
 - Expanding the range of modelled AEP events
 - Incorporating future climate change scenarios to estimate evolving flood damages, enabling a dynamic representation of AAD over time (i.e. increasing AAD)
- Increase the accuracy of benefit-cost calculations by:
 - Considering operational (Opex) costs for other mitigation options, such as for the levees, to reflect full life-cycle costs over the design period

Potential improvements to the benefit-cost ratio could be achieved by implementing a mixed program of works combining voluntary house purchase and retrofitting of building materials. For example, properties with the highest AAD, indicating frequent flooding (e.g., within the 1-in-10 or 1-in-20-year flood zones), could be targeted for voluntary house purchase. Meanwhile, properties with a lower likelihood of regular flooding (beyond the 1-in-20-year zones) could be addressed through retrofitting with flood-resilient building materials.

However, the effectiveness of voluntary house purchase is highly dependent on property values. Under current conditions, the highest B-C ratio achieved for an individual dwelling is 0.7. For this option to become economically viable, this B-C ratio would need to increase, which would require either a reduction in property values, an increase in AAD due to greater flood exposure, or a combination of both.



6 SUMMARY

Flood damages, expressed as Average Annual Damages (AAD), have been assessed for the township of Aireys Inlet based on flood modelling of Painkalac Creek undertaken as part of the *Flood Mitigation Adaptation for Painkalac Creek Estuary Study*.

Under the current approach of berm openings to reduce flood impacts, the average annual cost of flooding (AAD) is estimated to be \$28,210. Without opening the berm (berm-closed scenario) the average cost would be \$273,554 per year. These results demonstrate the effectiveness of berm opening at mitigating flood risk at present day.

Ten further mitigation options were investigated to assess their feasibility in reducing flood impacts and damages within the estuary, including:

- Water sensitive urban design (WSUD)
- Dam storage at 50% capacity
- Retarding basin
- Rewilding of the floodplain
- Levee
- Raising the Great Ocean Road and adding culverts
- Berm opening (existing practice)
- Berm height management (berm “grooming”)
- Voluntary house purchase (buy-back)
- Retrofitting building materials

Following an initial screening assessment, WSUD and dam storage were found to have negligible impact on flood levels and were not taken forward into an AAD assessment. The AAD assessment was therefore undertaken for the remaining eight options.

Each option was tested using the hydraulic model, with model outputs post-processed to derive an updated AAD. Cost estimates for each option (Costs) were then compared against the corresponding reduction in AAD relative to the existing case (Benefits) to inform a net present value assessment.

A wide range of benefit–cost (B-C) ratios was returned. The least financially viable options were those involving high construction costs without directly addressing the flow constriction caused by the berm, which represents a key control point for flood conveyance within the system. In particular, the retarding basin and the option to raise the Great Ocean Road and add culverts exhibited poor B-C ratios.

Although voluntary house purchase was effective in reducing flood risk, its high cost resulted in poor financial viability.

The most financially viable options were those that directly addressed the flow constriction caused by the berm and had relatively low ongoing costs, namely berm opening (the current management practice) and berm height management (berm grooming). However, these options are less favourable to some community groups due to the ongoing manual interruption of the estuary’s natural opening regime.

Options with moderate financial viability included construction of a levee and retrofitting of building materials. While the levee option was highly effective in reducing flood risk, it would result in notable visual and amenity impacts.

It is recommended that the retrofitting of building materials be investigated in greater detail to improve the level of detail in the financial assessment and to potentially optimise the effectiveness of this approach.



7 REFERENCES

Queensland Reconstruction Authority (QRA) (2019) *Flood Resilient Building Guidance for Queensland Homes, Version 1.0*, February 2019. Available at: <https://www.qra.qld.gov.au/sites/default/files/2019-02/Flood%20Resilience%20Building%20Guidance%20for%20Queensland%20Homes%20%28February%202019%29.pdf>



APPENDIX A ANNUAL AVERAGE DAMAGES SUMMARY



Present R07_C Scenario

ARI (years) AEP	200yr 0.005	100yr 0.01	50yr 0.02	20yr 0.05	10yr 0.1	5yr 0.2
Residential Buildings Flooded Above Floor	41	38	32	22	10	3
Commercial Buildings Flooded Above Floor	7	5	4	2	0	0
Properties Flooded Below Floor	10	13	16	18	21	13
Total Properties Flooded	58	56	52	42	31	16
Direct Potential External Damage Cost	\$423,619	\$361,512	\$291,618	\$176,392	\$76,355	\$20,573
Direct Potential Residential Damage Cost	\$3,840,591	\$3,357,499	\$2,762,354	\$1,720,272	\$763,545	\$205,731
Direct Potential Commercial Damage Cost	\$395,603	\$257,618	\$153,828	\$43,643	\$0	\$0
Total Direct Potential Damage Cost	\$4,659,813	\$3,976,629	\$3,207,800	\$1,940,307	\$839,900	\$226,304
Total Actual Damage Cost (0.8*Potential)	\$3,727,851	\$3,181,303	\$2,566,240	\$1,552,245	\$671,920	\$181,043
Infrastructure Damage Cost	\$97,253	\$87,993	\$77,390	\$58,167	\$27,956	\$18,787
Indirect Clean Up Cost (commercial only)	\$118,681	\$77,285	\$46,148	\$13,093	\$0	\$0
Indirect Residential Relocation Cost						
Indirect Emergency Response Cost						
Total Indirect Cost	\$118,681	\$77,285	\$46,148	\$13,093	\$0	\$0
Total Cost	\$3,943,785	\$3,346,582	\$2,689,779	\$1,623,505	\$699,875	\$199,830
Average Annual Damage (AAD)	\$216,176.73					

Figure A-1 AAD for the retarding basin

2040 R07_F Scenario

ARI (years) AEP	200yr 0.005	100yr 0.01	50yr 0.02	20yr 0.05	10yr 0.1	5yr 0.2
Residential Buildings Flooded Above Floor	41	37	31	22	10	6
Commercial Buildings Flooded Above Floor	6	5	4	2	0	0
Properties Flooded Below Floor	8	11	11	15	20	14
Total Properties Flooded	55	53	46	39	30	20
Direct Potential External Damage Cost	\$418,550	\$354,933	\$275,944	\$177,293	\$80,416	\$35,712
Direct Potential Residential Damage Cost	\$3,805,980	\$3,298,551	\$2,621,609	\$1,725,530	\$804,156	\$357,118
Direct Potential Commercial Damage Cost	\$379,518	\$250,776	\$137,826	\$47,395	\$0	\$0
Total Direct Potential Damage Cost	\$4,604,048	\$3,904,260	\$3,035,379	\$1,950,218	\$884,572	\$392,830
Total Actual Damage Cost (0.8*Potential)	\$3,683,238	\$3,123,408	\$2,428,303	\$1,560,174	\$707,657	\$314,264
Infrastructure Damage Cost	\$97,017	\$88,397	\$71,981	\$60,777	\$31,277	\$19,901
Indirect Clean Up Cost (commercial only)	\$113,855	\$75,233	\$41,348	\$14,219	\$0	\$0
Indirect Residential Relocation Cost						
Indirect Emergency Response Cost						
Total Indirect Cost	\$113,855	\$75,233	\$41,348	\$14,219	\$0	\$0
Total Cost	\$3,894,111	\$3,287,038	\$2,541,631	\$1,635,169	\$738,934	\$334,165
Average Annual Damage (AAD)	\$222,755.78					

Figure A-2 AAD for the rewilding of the floodplain



Present R07_B Scenario

ARI (years) AEP	200yr 0.005	100yr 0.01	50yr 0.02	20yr 0.05	10yr 0.1	5yr 0.2
Residential Buildings Flooded Above Floor	3	2	2	1	0	0
Commercial Buildings Flooded Above Floor	0	0	0	0	0	0
Properties Flooded Below Floor	0	1	1	1	2	1
Total Properties Flooded	3	3	3	2	2	1
Direct Potential External Damage Cost	\$22,797	\$17,027	\$15,574	\$6,372	\$0	\$0
Direct Potential Residential Damage Cost	\$227,971	\$170,270	\$155,741	\$63,720	\$0	\$0
Direct Potential Commercial Damage Cost	\$0	\$0	\$0	\$0	\$0	\$0
Total Direct Potential Damage Cost	\$250,768	\$187,297	\$171,315	\$70,092	\$0	\$0
Total Actual Damage Cost (0.8*Potential)	\$200,614	\$149,838	\$137,052	\$56,074	\$0	\$0
Infrastructure Damage Cost	\$43,226	\$40,813	\$37,110	\$28,740	\$18,543	\$4,584
Indirect Clean Up Cost (commercial only)	\$0	\$0	\$0	\$0	\$0	\$0
Indirect Residential Relocation Cost						
Indirect Emergency Response Cost						
Total Indirect Cost	\$0	\$0	\$0	\$0	\$0	\$0
Total Cost	\$243,841	\$190,651	\$174,162	\$84,813	\$18,543	\$4,584
Average Annual Damage (AAD)	\$10,535.18					

Figure A-3 AAD for the levee option

Present R07_A Scenario

ARI (years) AEP	200yr 0.005	100yr 0.01	50yr 0.02	20yr 0.05	10yr 0.1	5yr 0.2
Residential Buildings Flooded Above Floor	41	38	32	23	10	10
Commercial Buildings Flooded Above Floor	7	5	4	2	1	0
Properties Flooded Below Floor	13	13	17	19	22	15
Total Properties Flooded	61	56	53	44	33	25
Direct Potential External Damage Cost	\$425,745	\$364,238	\$295,079	\$187,062	\$84,111	\$70,745
Direct Potential Residential Damage Cost	\$3,852,138	\$3,378,142	\$2,788,062	\$1,819,181	\$836,696	\$707,446
Direct Potential Commercial Damage Cost	\$405,312	\$264,235	\$162,732	\$51,441	\$4,412	\$0
Total Direct Potential Damage Cost	\$4,683,195	\$4,006,615	\$3,245,873	\$2,057,684	\$925,219	\$778,191
Total Actual Damage Cost (0.8*Potential)	\$3,746,556	\$3,205,292	\$2,596,699	\$1,646,147	\$740,175	\$622,552
Infrastructure Damage Cost	\$95,369	\$87,112	\$77,937	\$65,545	\$57,072	\$53,902
Indirect Clean Up Cost (commercial only)	\$121,594	\$79,271	\$48,820	\$15,432	\$1,324	\$0
Indirect Residential Relocation Cost						
Indirect Emergency Response Cost						
Total Indirect Cost	\$121,594	\$79,271	\$48,820	\$15,432	\$1,324	\$0
Total Cost	\$3,963,518	\$3,371,675	\$2,723,456	\$1,727,125	\$798,570	\$676,455
Average Annual Damage (AAD)	\$252,465.97					

Figure A-4 AAD for raising the Great Ocean Road and adding culverts



Present R03 Scenario						
ARI (years) AEP	200yr 0.005	100yr 0.01	50yr 0.02	20yr 0.05	10yr 0.1	5yr 0.2
Residential Buildings Flooded Above Floor	26	17	10	1	0	0
Commercial Buildings Flooded Above Floor	2	1	0	0	0	0
Properties Flooded Below Floor	17	17	15	1	2	1
Total Properties Flooded	45	35	25	2	2	1
Direct Potential External Damage Cost	\$209,558	\$122,637	\$63,849	\$5,488	\$0	\$0
Direct Potential Residential Damage Cost	\$2,050,513	\$1,220,896	\$638,494	\$54,880	\$0	\$0
Direct Potential Commercial Damage Cost	\$45,066	\$5,470	\$0	\$0	\$0	\$0
Total Direct Potential Damage Cost	\$2,305,137	\$1,349,003	\$702,343	\$60,368	\$0	\$0
Total Actual Damage Cost (0.8*Potential)	\$1,844,110	\$1,079,202	\$561,875	\$48,294	\$0	\$0
Infrastructure Damage Cost	\$60,886	\$38,216	\$28,670	\$16,373	\$7,246	\$1,595
Indirect Clean Up Cost (commercial only)	\$13,520	\$1,641	\$0	\$0	\$0	\$0
Indirect Residential Relocation Cost						
Indirect Emergency Response Cost						
Total Indirect Cost	\$13,520	\$1,641	\$0	\$0	\$0	\$0
Total Cost	\$1,918,515	\$1,119,059	\$590,545	\$64,667	\$7,246	\$1,595
Average Annual Damage (AAD)	\$28,210.07					

Figure A-5 AAD for berm opening (present management practice)

Present R07_F Scenario						
ARI (years) AEP	200yr 0.005	100yr 0.01	50yr 0.02	20yr 0.05	10yr 0.1	5yr 0.2
Residential Buildings Flooded Above Floor	37	31	24	11	2	0
Commercial Buildings Flooded Above Floor	4	4	2	0	0	0
Properties Flooded Below Floor	13	14	19	22	12	9
Total Properties Flooded	54	49	45	33	14	9
Direct Potential External Damage Cost	\$333,729	\$270,441	\$193,408	\$86,305	\$13,992	\$0
Direct Potential Residential Damage Cost	\$3,140,559	\$2,600,774	\$1,886,681	\$863,049	\$139,918	\$0
Direct Potential Commercial Damage Cost	\$196,730	\$103,636	\$47,401	\$0	\$0	\$0
Total Direct Potential Damage Cost	\$3,671,018	\$2,974,851	\$2,127,490	\$949,354	\$153,910	\$0
Total Actual Damage Cost (0.8*Potential)	\$2,936,814	\$2,379,881	\$1,701,992	\$759,483	\$123,128	\$0
Infrastructure Damage Cost	\$85,127	\$76,357	\$60,094	\$25,743	\$18,478	\$12,431
Indirect Clean Up Cost (commercial only)	\$59,019	\$31,091	\$14,220	\$0	\$0	\$0
Indirect Residential Relocation Cost						
Indirect Emergency Response Cost						
Total Indirect Cost	\$59,019	\$31,091	\$14,220	\$0	\$0	\$0
Total Cost	\$3,080,961	\$2,487,329	\$1,776,306	\$785,226	\$141,605	\$12,431
Average Annual Damage (AAD)	\$104,534.52					

Figure A-6 AAD for berm height management (berm “grooming”)



Present R07 Scenario						
ARI (years) AEP	200yr 0.005	100yr 0.01	50yr 0.02	20yr 0.05	10yr 0.1	5yr 0.2
Residential Buildings Flooded Above Floor	42	38	34	27	13	10
Commercial Buildings Flooded Above Floor	7	5	4	2	1	0
Properties Flooded Below Floor	13	13	14	16	20	20
Total Properties Flooded	62	56	52	45	34	30
Direct Potential External Damage Cost	\$431,351	\$369,212	\$308,670	\$213,288	\$98,734	\$74,385
						\$0
Direct Potential Residential Damage Cost	\$3,902,609	\$3,417,054	\$2,907,416	\$2,071,337	\$977,484	\$743,848
Direct Potential Commercial Damage Cost	\$410,898	\$275,069	\$179,281	\$61,545	\$9,855	\$0
Total Direct Potential Damage Cost	\$4,744,858	\$4,061,335	\$3,395,367	\$2,346,170	\$1,086,073	\$818,233
Total Actual Damage Cost (0.8*Potential)	\$3,795,886	\$3,249,068	\$2,716,293	\$1,876,936	\$868,858	\$654,586
Infrastructure Damage Cost	\$97,875	\$89,415	\$78,695	\$62,822	\$41,899	\$25,840
Indirect Clean Up Cost (commercial only)	\$123,269	\$82,521	\$53,784	\$18,464	\$2,957	\$0
Indirect Residential Relocation Cost						
Indirect Emergency Response Cost						
Total Indirect Cost	\$123,269	\$82,521	\$53,784	\$18,464	\$2,957	\$0
Total Cost	\$4,017,031	\$3,421,004	\$2,848,773	\$1,958,222	\$913,714	\$680,427
Average Annual Damage (AAD)	\$273,554.32					

Figure A-7 AAD for berm closed (used for voluntary house purchase and retrofitting building materials)



APPENDIX B BILL OF QUANTITIES





Project:	Painkalac_Creek				
Client:	n/a				
PM (full name):	n/a				
Water Technology Job Number:	25010180				
Design Arrangement :	Raise GOR with culverts				
BOQ Rev:	1b				
 WATER TECHNOLOGY WATER, COASTAL & ENVIRONMENTAL CONSULTANTS					
	Relevant Design Plans:				
	n/a				
	Bill of Quantity				
Item	Description of Works	Quantity	Unit	Rate	Price
1	Site Establishment				
1.1	Site establishment including provision of access, survey setout, preparation of site management plan and environmental management plan, provision of temporary site fencing, CHMP fencing, office compounds, locations of existing services, insurances, road opening permits, any permits and fees, de-establishment from site and tidy up works, and other works included on the drawings but not specified.	1	Item	Contractor Indirect Costs are measured on the Summary Page.	\$ 7,500
2	Earth Works				
2.1	Bulk earthworks Including stripping and stockpiling topsoil were suitable for reuse, trimming and compaction of subgrades for access tracks, weirs, footpaths, landscape grading, allotment grading & placing, spreading & compaction of topsoil on all disturbed areas. All as specified			\$ 1	
a)	Cut to export offsite	875	cu.m	\$ 96	\$ 84,000
a)	Fill to import	1	cu.m	\$ 65	\$ 65
b)	Cut to fill	1	cu.m	\$ 49	\$ 49
d)	Scrape and stockpile topsoil and subsequently place and compact	3000	sq.m	\$ 8	\$ 24,000
2.2	Hyrdoseed disturbed surfaces due to earthworks.	3000	sq.m	\$ 8	\$ 24,000
3	Drainage Infrastructure				
3.1	Excavation supply, laying, bedding and backfilling of stormwater pipes of classes and types as approved for the following sizes. Including obtaining relevant works permits. Inclusive of anti seepage collars where specified.				
a)	Select Backfill				
i)	2700 x 2100mm Box Culverts	1638	l.m	\$ 6,500	\$ 10,647,000
ii)	Box Culvert Slab (approx. 200mm reinforced)	900	cu.m	\$ 750	\$ 675,000
3.4	Headwalls	2	no.	\$ 409,500	\$ 819,000
4	Landscaping				
	n/a				
5	Incidental Works				
5.2	Rock Beach and lining	2500	sq.m	\$ 172	\$ 430,456
	reinsta footpath	900	sq.m	\$ 100	\$ 90,000
	Road (bitumen surface, approx. 200mm deep)	2700	sq.m	\$ 150	\$ 405,000
			cu.m		
5.4	Safety Barrier	540	l.m	\$ 300	\$ 162,000
6	Provisional Items				
	na				
7	Provisional sum (10%)				Costs on the Summary Page
8				Subtotal	\$ 13,368,070
9				GST	\$ 1,336,807
10				Total	\$ 14,704,877



Project: Painkalac_Creek
Client: n/a
PM (full name): n/a
er Technology Job Number: 25010180
Design Arrangement : Raise GOR with culverts
BOQ Rev: 1b



2022/23 Melbourne Water BNI Estimate			
Item			
			Medium Estimate
1	Investigation	Investigations	
		Investigations costs (allow 2% of Total Construction Costs)	\$390,173
		Sub-total Pre-BNI Costs	\$390,173
2	Concept Design	Feasibility	
2.1	Concept Design	Survey - consultant (allow 0.5% of Total Construction Costs)	\$97,543
2.2	Concept Design	Concept design - consultant (allow 1.5% of Total Construction Costs)	\$292,630
		Sub-total Feasibility Costs	\$390,173
3	Functional Design	Functional Design	
3.1	Functional Design	Functional design - consultant (allow 3% of Total Construction Costs)	\$585,260
		Sub-total Functional Design Costs	\$585,260
4	Detailed Design	Detailed Design	
4.1	Detailed Design	Detailed design - consultant (allow 5% of Total Construction Costs)	\$668,403
		Sub-total Detailed Design Costs	\$668,403
5	Construction	Construction	
5.1	Construction	SP Direct Costs - Civil and Earthworks (based on area rate incl site establishment, plant & equip & PM & Fee) (see separate estimate tabs.)	\$13,368,070
5.2	Construction	SP Indirect Costs (PM, Site Operations, etc) - 10% of SP Direct & Indirect Costs	\$1,336,807
5.3	Construction	SP Design Development Contingency - 20% of SP Direct & Indirect Costs	\$2,940,975
5.4	Construction	SP Construction Risk Contingency - allow 10% of SP Direct & Indirect Costs	\$1,470,488
5.5	Construction	SP Margin	included
5.6	Construction	Construction Design support - consultant - allow 2% of SP Direct & Indirect Costs + Risk Contingency + Margin)	\$382,327
5.7	Construction	Community engagement	\$10,000
5.8	Construction	Project Management	included
		Sub-total Construction Costs	\$19,508,667
6		Total Construction costs	\$21,542,677
10		Project Base Cost Estimate	\$21,542,677
		Rounding	-\$42,677
		Total Base Estimate (rounded)	\$21,500,000



Project: Painkalac_Creek
Client: n/a
PM (full name): n/a
Water Technology Job Number: 25010180
Design Arrangement : Retarding Basin
BOQ Rev: 1b



	Relevant Design Plans:					
	n/a					
	Bill of Quantity					
	Item	Description of Works	Quantity	Unit	Rate	Price
	1	Site Establishment				
	1.1	Site establishment including provision of access, survey setout, preparation of site management plan and environmental management plan, provision of temporary site fencing, CHMP fencing, office compounds, locations of existing services, insurances, road opening permits, any permits and fees, de-establishment from site and tidy up works, and other works included on the drawings but not specified.	1	Item	Contractor Indirect Costs are measured on the Summary Page.	\$ 7,500
	2	Earth Works				
	2.1	Bulk earthworks Including stripping and stockpiling topsoil were suitable for reuse, trimming and compaction of subgrades for access tracks, weirs, footpaths, landscape grading, allotment grading & placing, spreading & compaction of topsoil on all disturbed areas. All as specified			\$ 1	
	a)	Cut to export offsite	150100	cu.m	\$ 55	\$ 8,255,500
	a)	Fill to import	1	cu.m	\$ 65	\$ 65
	b)	Cut to fill	1	cu.m	\$ 49	\$ 49
	d)	Scrape and stockpile topsoil and subsequently place and compact	80500	sq.m	\$ 5	\$ 402,500
	2.2	Hyrdoseed disturbed surfaces due to earthworks.	80500	sq.m	\$ 5	\$ 402,500
	3	Drainage Infrastructure				
	3.1	na				
	4	Landscaping				
		Terrestrial planting tube stock. Including supply, planting, guards, and applicable netting.	20125	number	\$ 10	\$ 201,250
	5	Incidental Works				
		na				
	6	Provisional Itens				
		na				
	7	Provisional sum (10%)				Costs on the Summary Page
	8				Subtotal	\$ 9,269,364
	9				GST	\$ 926,936
	10				Total	\$ 10,196,300



Project: Painkalac_Creek
Client: n/a
PM (full name): n/a
er Technology Job Number: 25010180
Design Arrangement : Retarding Basin
BOQ Rev: 1b



2022/23 Melbourne Water BNI Estimate			
Item			
			Medium Estimate
1	Investigation	Investigations	
		Investigations costs (allow 2% of Total Construction Costs)	\$249,805
		Sub-total Pre-BNI Costs	\$249,805
2	Concept Design	Feasibility	
2.1	Concept Design	Survey - consultant	\$31,226
2.2	Concept Design	Concept design - consultant	\$62,451
		Sub-total Feasibility Costs	\$93,677
3	Functional Design	Functional Design	
3.1	Functional Design	Functional design - consultant (allow 1% of Total Construction Costs)	\$124,903
		Sub-total Functional Design Costs	\$124,903
4	Detailed Design	Detailed Design	
4.1	Detailed Design	Detailed design - consultant (allow 2% of SP Direct Construction Costs)	\$185,387
		Sub-total Detailed Design Costs	\$185,387
5	Construction	Construction	
5.1	Construction	SP Direct Costs - Civil and Earthworks (based on area rate incl site establishment, plant & equip & PM & Fee) (see separate estimate tabs.)	\$9,269,364
5.2	Construction	SP Indirect Costs (PM, Site Operations, etc) - 10% of SP Direct & Indirect Costs	\$926,936
5.3	Construction	SP Design Development Contingency - 10% of SP Direct & Indirect Costs	\$1,019,630
5.4	Construction	SP Construction Risk Contingency - allow 10% of SP Direct & Indirect Costs	\$1,019,630
5.5	Construction	SP Margin	included
5.6	Construction	Construction Design support - consultant - allow 2% of SP Direct & Indirect Costs + Risk Contingency + Margin)	\$244,711
5.7	Construction	Community engagement	\$10,000
5.8	Construction	Project Management	included
		Sub-total Construction Costs	\$12,490,272
6		Total Construction costs	\$13,144,044
10		Project Base Cost Estimate	\$13,144,044
		Rounding	-\$44,044
		Total Base Estimate (rounded)	\$13,100,000



Project: Painkalac_Creek
Client: n/a
PM (full name): n/a
Water Technology Job Number: 25010180
Design Arrangement : Levee
BOQ Rev: 1b



Relevant Design Plans:					
n/a					
Bill of Quantity					
Item	Description of Works	Quantity	Unit	Rate	Price
1	Site Establishment				
1.1	Site establishment including provision of access, survey setout, preparation of site management plan and environmental management plan, provision of temporary site fencing, CHMP fencing, office compounds, locations of existing services, insurances, road opening permits, any permits and fees, de-establishment from site and tidy up works, and other works included on the drawings but not specified.	1	Item	Contractor Indirect Costs are measured on the Summary Page.	\$ 7,500
2	Earth Works				
2.1	Bulk earthworks Including stripping and stockpiling topsoil were suitable for reuse, trimming and compaction of subgrades for access tracks, weirs, footpaths, landscape grading, allotment grading & placing, spreading & compaction of topsoil on all disturbed areas. All as specified			\$ 1	
a)	Cut to export offsite	1	cu.m	\$ 96	\$ 96
a)	Fill to import	13000	cu.m	\$ 65	\$ 845,000
b)	Cut to fill	1	cu.m	\$ 49	\$ 49
d)	Scrape and stockpile topsoil and subsequently place and compact	19050	sq.m	\$ 7	\$ 133,350
2.2	Hyrdoseed disturbed surfaces due to earthworks.	19050	sq.m	\$ 7	\$ 133,350
3	Drainage Infrastructure				
3.1	Excavation supply, laying, bedding and backfilling of stormwater pipes of classes and types as approved for the following sizes. Including obtaining relevant works permits. Inclusive of anti seepage collars where specified.				
a)	Piped levee outfall crossing (inc headwall, endwall, pipe (assume moderate sizes on ave), and flap/gate valve	14	Item	\$ 27,250	\$ 381,500
4	Landscaping				
	n/a				
5	Incidental Works				
	GoR Flood Gate	16	l.m	\$ 12,000	\$ 192,000
	reinsta footpath	900	sq.m	\$ 100	\$ 90,000
	Raising Road (inc all pavement, fill import, and incidentals. Road list assumed less than 650mm	240	l.m	\$ 4,000	\$ 960,000
	Retaining wall	480	l.m	\$ 2,000	\$ 960,000
6	Provisional Items				
	na				
7	Provisional sum (10%)				Costs on the Summary Page
8				Subtotal	\$ 3,702,845
9				GST	\$ 370,285
10				Total	\$ 4,073,130



Project: Painkalac_Creek
Client: n/a
PM (full name): n/a
er Technology Job Number: 25010180
Design Arrangement : Levee
BOQ Rev: 1b



2022/23 Melbourne Water BNI Estimate			
Item			
			Medium Estimate
1	Investigation	Investigations	
		Investigations costs (allow 2% of Total Construction Costs)	\$120,172
		Sub-total Pre-BNI Costs	\$120,172
2	Concept Design	Feasibility	
2.1	Concept Design	Survey - consultant (allow 1% of Total Construction Costs)	\$60,086
2.2	Concept Design	Concept design - consultant (allow 2% of Total Construction Costs)	\$120,172
		Sub-total Feasibility Costs	\$180,258
3	Functional Design	Functional Design	
3.1	Functional Design	Functional design - consultant (allow 3% of Total Construction Costs)	\$180,258
		Sub-total Functional Design Costs	\$180,258
4	Detailed Design	Detailed Design	
4.1	Detailed Design	Detailed design - consultant (allow 5% of SP Direct Construction Costs)	\$185,142
		Sub-total Detailed Design Costs	\$185,142
5	Construction	Construction	
5.1	Construction	SP Direct Costs - Civil and Earthworks (based on area rate incl site establishment, plant & equip & PM & Fee) (see separate estimate tabs.)	\$3,702,845
5.2	Construction	SP Indirect Costs (PM, Site Operations, etc) - 15% of SP Direct & Indirect Costs	\$555,427
5.3	Construction	SP Design Development Contingency - 25% of SP Direct & Indirect Costs	\$1,064,568
5.4	Construction	SP Construction Risk Contingency - allow 10% of SP Direct & Indirect Costs	\$425,827
5.5	Construction	SP Margin	included
5.6	Construction	Construction Design support - consultant - allow 4% of SP Direct & Indirect Costs + Risk Contingency + Margin)	\$229,947
5.7	Construction	Community engagement	\$30,000
5.8	Construction	Project Management	included
		Sub-total Construction Costs	\$6,008,614
6		Total Construction costs	\$6,674,445
10		Project Base Cost Estimate	\$6,674,445
		Rounding	\$25,555
		Total Base Estimate (rounded)	\$6,700,000



BOQ Rev: 1b



Surf Coast Shire | 13 April 2026
Flood Mitigation Adaptation for Painkalac Creek Estuary, Aireys Inlet



Project: Painkalac_Creek
Client: n/a
PM (full name): n/a
er Technology Job Number: 25010180
Design Arrangement : Rewilding of floodplain
BOQ Rev: 1b



2022/23 Melbourne Water BNI Estimate			
Item			
			Medium Estimate
1	Investigation	Investigations	
		Investigations costs (allow 2% of Delivery Costs) (No allowance for Cultural Heritage Assessment)	\$7,687
		Sub-total Pre-BNI Costs	\$7,687
2	Concept Design	Feasibility	
2.1	Concept Design	Survey - consultant (allow 2% of Delivery Costs)	\$7,687
2.2	Concept Design	Concept design - consultant (allow 2% of Delivery Costs)	\$7,687
		Sub-total Feasibility Costs	\$15,375
3	Functional Design	Functional Design	
3.1	Functional Design	Functional design - consultant (allow 2% of Total Delivery Costs)	\$7,687
		Sub-total Functional Design Costs	\$7,687
4	Detailed Design	Detailed Design	
4.1	Detailed Design	Detailed design - consultant (allow 5% of SP Direct Delivery Costs)	\$14,228
		Sub-total Detailed Design Costs	\$14,228
5	Construction	Construction	
5.1	Construction	SP Direct Costs (see separate estimate tabs.)	\$284,562
5.2	Construction	SP Indirect Costs (PM, Site Operations, etc) - 10% of SP Direct & Indirect Costs	\$28,456
5.3	Construction	SP Design Development Contingency - 10% of SP Direct & Indirect Costs	\$31,302
5.4	Construction	SP Construction Risk Contingency - allow 5% of SP Direct & Indirect Costs	\$15,651
5.5	Construction	SP Margin	included
5.6	Construction	Construction Design support - consultant - allow 4% of SP Direct & Indirect Costs + Risk Contingency + Margin)	\$14,399
5.7	Construction	Community engagement	\$10,000
5.8	Construction	Project Management	included
		Sub-total Construction Costs	\$384,370
6		Total Construction costs	\$429,347
10		Project Base Cost Estimate	\$429,347
		Rounding	\$653
		Total Base Estimate (rounded)	\$430,000

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