Manly Hydraulics Laboratory

UNSW Sydney Water Research Laboratory

Seawalls and Sandy Beaches Case Study Wamberal Beach

2022 NSW Coastal Conference

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Acknowledgement of Country

We acknowledge the people who are the Traditional Custodians of the Land on which we work and study, and show respect to Elders past and present, and extend that respect to everyone present. I acknowledge the Darkinjung people who are the Traditional Custodians of the land on which this study took place.

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Presentation overview

- Project aims and overview
- Wamberal Beach - Study Site - Review of previous studies
  - 2020 Storm erosion – emergency response and data capture
- Seawall concept design options for Wamberal Beach
- Cost-benefit analysis of seawall options
- Assessing seawall impacts on beach amenity
- Sand nourishment for beach amenity
- Wamberal Beach Real-time Coastal Monitoring
- Next steps and opportunities

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Project aim and overview

- Certified Gosford Beaches Coastal Zone Management Plan (CZMP, 2017) priority management issues with the primary objective:

"to protect and preserve the beach environments, beach amenity, public access and social fabric of the Open Coast and Broken Bay beaches while managing coastal hazard risks to people and the environment".

- Major actions recommended for Wamberal Beach from the CZMP (2017):
  - *TW11 Terminal protection - Council to action review, design and funding of terminal protection structure for Wamberal.*
  - *TW14 Investigate sources of sand and feasibility of beach nourishment for Wamberal Beach.*
  - *TW15 Beach nourishment coupled with a terminal revetment to increase buffer against storm erosion.*

- CZMP did not include provisions for construction of a seawall

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Project aim and overview

In May 2020, Manly Hydraulics Laboratory (MHL) in association with the Water Research Laboratory (WRL) of UNSW Sydney and Balmoral Group Australia (BGA) were commissioned by Central Coast Council to undertake the *Wamberal Terminal Coastal Protection Assessment*.

Series of Reports:

1. Review of previous studies
2. Coastal protection amenity assessment
3. Seawall concept design options
4. Sand nourishment investigation
5. Provision of coastal monitoring (online webpage)
6. Cost benefit analysis and distributional analysis of options

Available: https://www.yourvoiceourcoast.com/wamberalerosion

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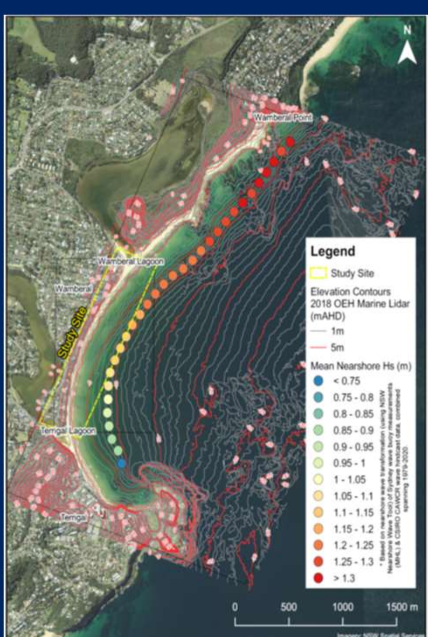
Wamberal Beach - Study Site & Review of Previous Studies



- Sandy embayment bounded by rocky reefs and headlands.
- Local region of elevated claystone
- Terrigal and Wamberal Lagoon
- Dune field to the north Wamberal Nature Reserve and Spoon Bay.
- Underlying recession of 0.2 m/year
- A Bruun Factor of about 43, that is, recession due to sea level rise (SLR) would be 43 times the SLR
- “Design” (nominally 100-year Annual Recurrence Interval ‘ARI’) storm erosion of 250 m3/m
- 68 dwellings potentially impacted by coastal hazards by 2050

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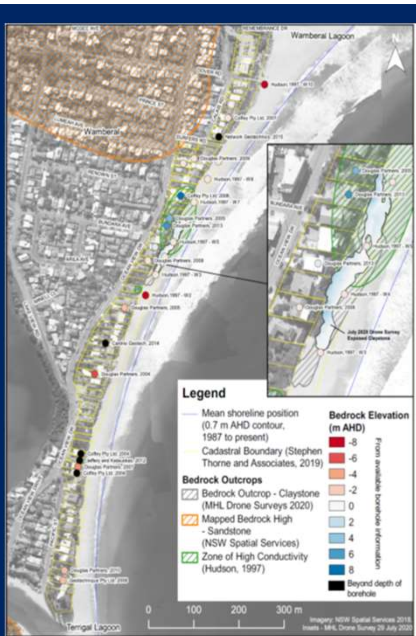
Wamberal Beach - Study Site & Review of Previous Studies



- Fine to medium grained quartz sands
- Region of elevated claystone/siltstone (~400m, exposed at depths -2 to +1 m AHD during storms)
- Extends into dune substrate
- Other locations bedrock typically deeper

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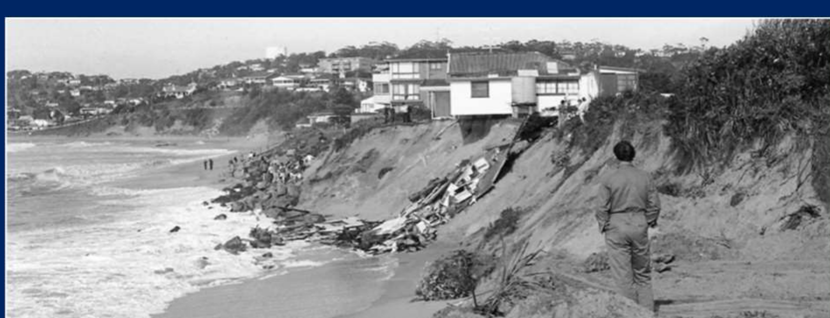
Wamberal Beach - Study Site & Review of Previous Studies

- A long history of coastal erosion and emergency response
- 1974 the Australian Army and SES undertook emergency rock and sandbag protection. Other materials also
- 1978 – two houses lost one resulting in the Egger legal case



- Large storms threatening properties 1997, 2007 and 2016, 2020 with continued emergency response
- Ad-hoc and emergency materials placed on beach

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Wamberal Beach – July 2020 Storm erosion

- 54 residents evacuated for their personal safety.
- Hazardous rubble and debris were strewn across the beach
- Partial undermining residential buildings
- 2,400 tonnes of rock, over 2,000 tonnes of rock bags and 4,000 tonnes of sand. Total cost $2.1M

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Wamberal Beach – July 2020 Storm erosion

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Wamberal Beach – July 2020 Storm erosion

- House-by house risk assessment
- Working with SES to inform evacuation
- X5 repeat drone surveys to monitor erosion scarp regression and dune slumping
- Mapping of existing materials / claystone buried in beach

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Wamberal Beach – July 2020 Storm erosion

- House-by house risk assessment
- Working with SES to inform Evacuation
- X5 repeat drone surveys to monitor erosion scarp regression and dune slumping
- Mapping of existing materials / claystone buried in beach

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Wamberal Beach – Toward a Long-Term Solution

- Review of 30+ studies (1980's to present) relevant to Wamberal beach coastal management
  - **All studies recommend seawall (terminal protection) and sand nourishment as most viable options for Wamberal**
  - Large scale sand nourishment constrained by the availability of an accessible sand source.
- Former Seabee Seawall detailed design (Lagoon to Lagoon) by WRL (1998) and EIS by MHL (2004)
  - Adopted by Council in 2004, however funding could not be secured.
- Coastal Zone Management Plan (2017) > terminal protection coupled with sand nourishment

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Seawall concept design options

Five Seawall concept designs

- Design parameters
- Concept design cross-sections
- Preliminary alignment
- Preliminary costings
- Advantages/disadvantages

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Seawall concept design options

Five concept design options:

1. **Basalt Rock Revetment -** $26.5M
2. **Sandstone Rock Revetment -** $25.0M
3. **Vertical Seawall** – $34.0M
4. **Vertical Seawall with rock toe protection -** $34.7M
5. **Tiered Vertical Seawall with Promenade -** $40.1M

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Seawall concept design options

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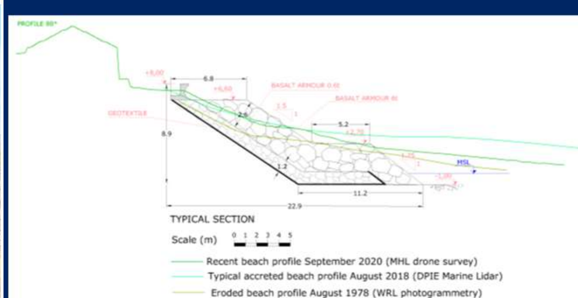

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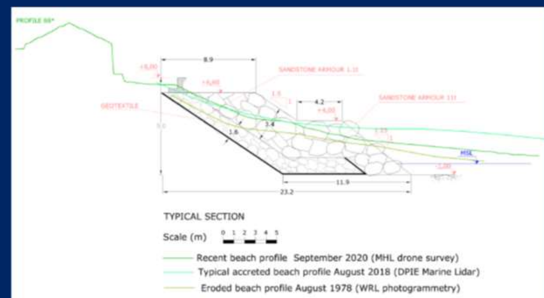

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Seawall concept design options

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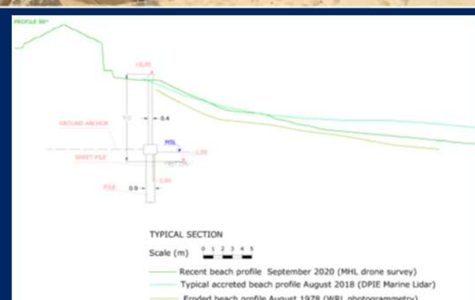

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Seawall concept design options

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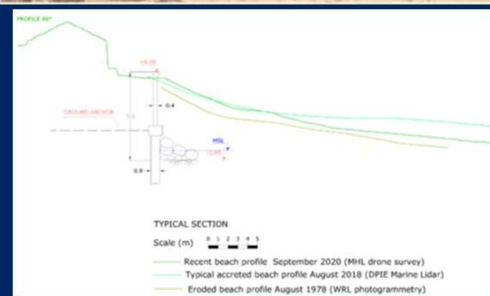

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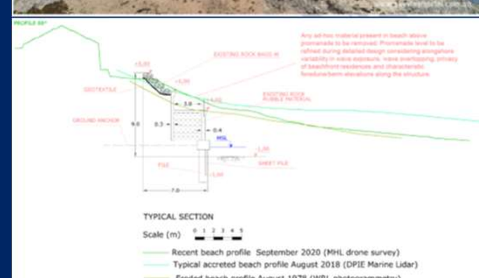

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Seawall concept design options

1. Basalt Rock Revetment

- Sloped rock revetment with 2 layers basalt primary armour. Wave return at crest
- Prelim cost: $26.5M
- Pros: Lower $, conventional, non-rigid, adaptable to SLR
- Cons: Larger footprint, higher encroachment, high impact on available beach width.
- E.g. Lennox head.

Belongil, Port Kembla

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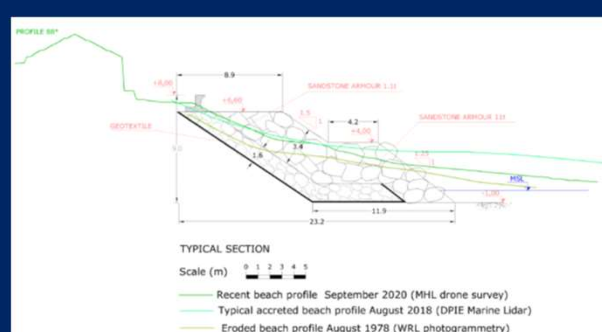
Seawall concept design options

2. Sandstone Rock Revetment

- Sloped rock revetment with 2 layers sandstone primary armour. Wave return at crest
- Prelim cost: $25.0M
- Pros: Lower $, conventional, non-rigid, adaptable to SLR, sandstone aesthetics
- Cons: Larger footprint, higher encroachment, high impact on available beach width, rock armour durability
- E.g. Collaroy



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Seawall concept design options

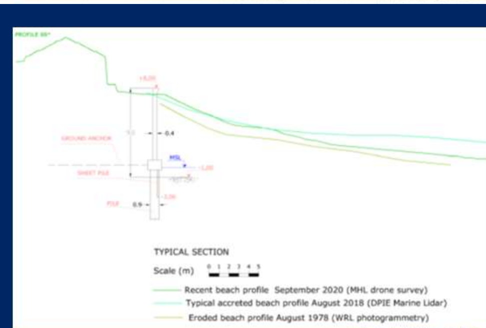
3. Vertical Seawall

- Concrete panel vertical seawall with piled foundations, sheetpile scour protection, wave return
- Prelim cost: $34.0M
- Pros: Smallest footprint, low encroachment and low impact on available beach width, adaptable to SLR
- Cons: Moderate to high $, vertical relief - visually imposing and public safety.
- E.g. Narrabeen,

Flynns Beach,

South Cronulla

Bondi



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Seawall concept design options

4. Vertical Seawall with rock toe protection

- Concrete panel vertical seawall with piled foundations, non-rigid toe protection, wave return
- Prelim cost: $34.7M
- Pros: Small footprint, non-rigid toe, low encroachment and low impact on available beach width, adaptable to SLR
- Cons: Moderate to high $, vertical relief - visually imposing and public safety.
- E.g. Narrabeen,

Flynns Beach,

South Cronulla

Bondi

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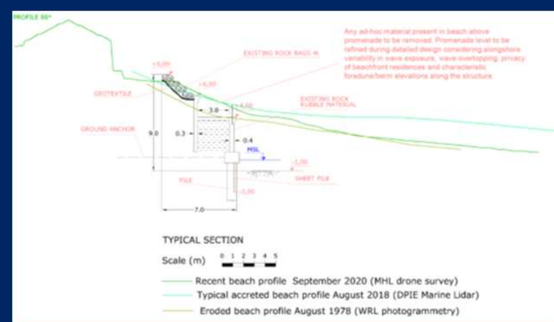
Seawall concept design options

5. Tiered Vertical Seawall with Promenade

- Tiered vertical wall, mid-level promenade, sloping backfill, piled foundations, wave return
- Prelim cost: $40.1M
- Pros: enhanced access & amenity, broader community benefits, reduced vertical relief, adaptable to SLR, relatively low encroachment, existing rock reuse opportunities
- Cons: Highest cost, more complex detailed design, privacy consideration, public access management during storms.
- E.g. Newcastle (City), Wollongong (Blue Mile)



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Seawall concept design options

Preliminary alignment: As far landward as practicable to minimise encroachment

Reviewed former Seabee Design as rear of structure for all options:

- Setback to existing buildings
- Relative to foredune erosion scarp
- Relative to characteristic shoreline curvature

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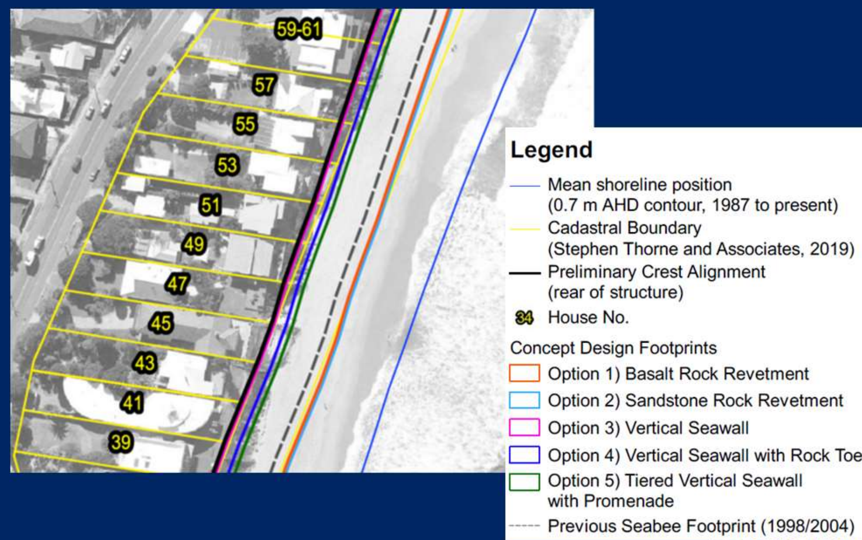
Seawall concept design options

Preliminary alignment: As far landward as practicable to minimise encroachment

All options aligned with common rear of structure alignment.

- ➢ Reduced encroachment of vertical compared to sloped structures



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Cost-benefit analysis of seawall options – Overview

- All options show positive BCR primarily driven by avoided loss of private property and land.
- Vertical wall options indicate highest BCR however relative differences are marginal and subject to sensitivity testing
  - Discount rates
  - Number of visitors
  - Promenade benefits

- ➢ CBA an important tool but not all assessment criteria can be monetarised…

Seawall Option	NPV ($M)	BCR
Basalt Rock Revetment	$33.1	1.94
Sandstone Rock Revetment	$33.2	1.95
Vertical Seawall	$53.7	2.43
Vertical Seawall with rock toe	$53.0	2.39
Tiered Vertical seawall with promenade	$51.2	1.96

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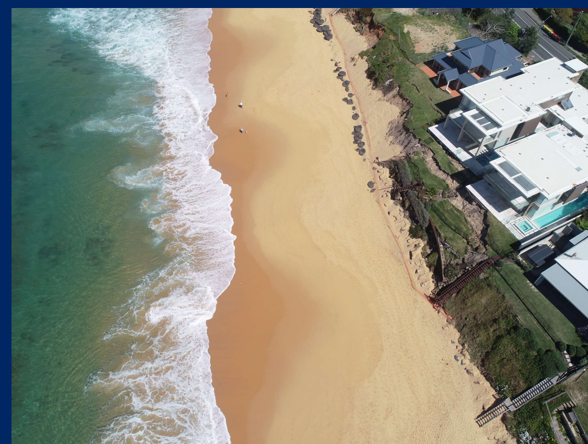
Assessing seawall impacts on beach amenity

- Seawall impacts on sandy beach a major concern for beachfront home owners and broader community raised during consultation
- Aspects of beach amenity :
  - Beach width impacts (WRL modelling)
  - Surf amenity
  - Post-storm ad-hoc protection debris
  - Visual amenity
  - Foreshore access
  - Safety



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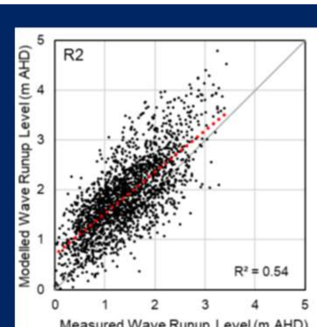
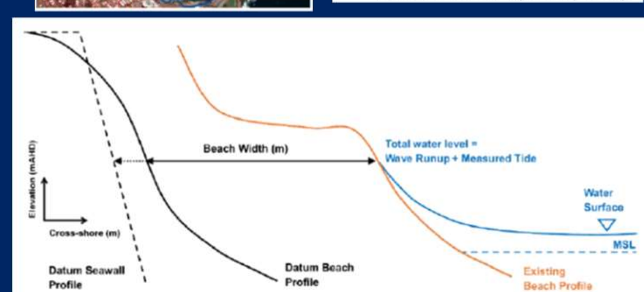
Assessing seawall impacts on beach amenity

Quantifying beach width impacts

- Hindcast dry beach width model
  - 10 year period 2010 - 2020
  - Hourly wave/tide data
  - Hourly wave runup estimates from Mase Equation (R2%, Rmax)
  - Measured beach profile data (RTK-GPS, Drone, aerial lidar)
  - Dry beach width timeseries for existing beach and seawall scenarios
  - X6 representative profile locations
- Calibrated against 10 months of hourly measured wave runup data from Wamberal Lidar Station.





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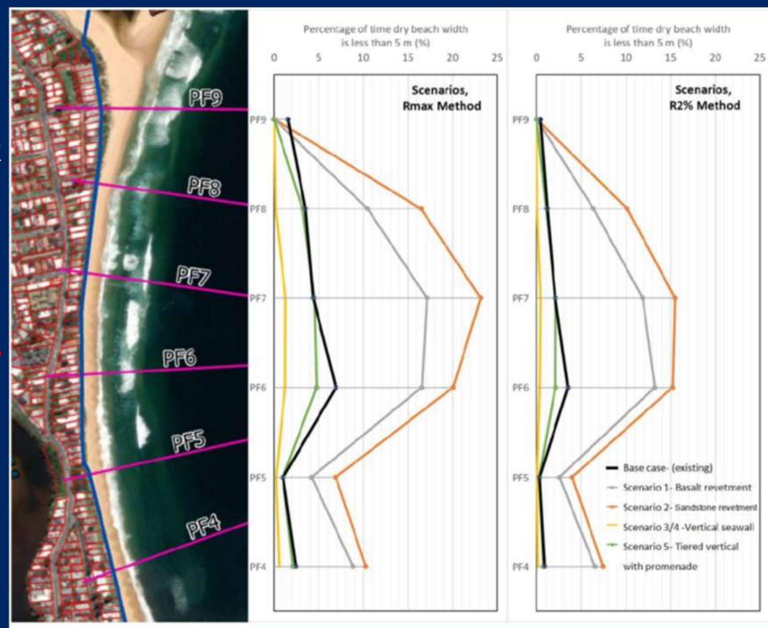
Assessing seawall impacts on beach amenity

Quantifying beach width impacts

Percentage of time less than a 5 m beach width:

- Existing beach (including ad-hoc rock protection): 1.4% to 3.3%
  (ie on average ~5-12 days/year)
- Basalt revetment: 6.8% to 9.5%
- Sandstone revetment: 8.7% to 12.8%
- Vertical seawall: 0.2% to 0.6%
- Tiered vertical seawall with promenade: 1.1% to 2.6%



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Assessing seawall impacts on beach amenity

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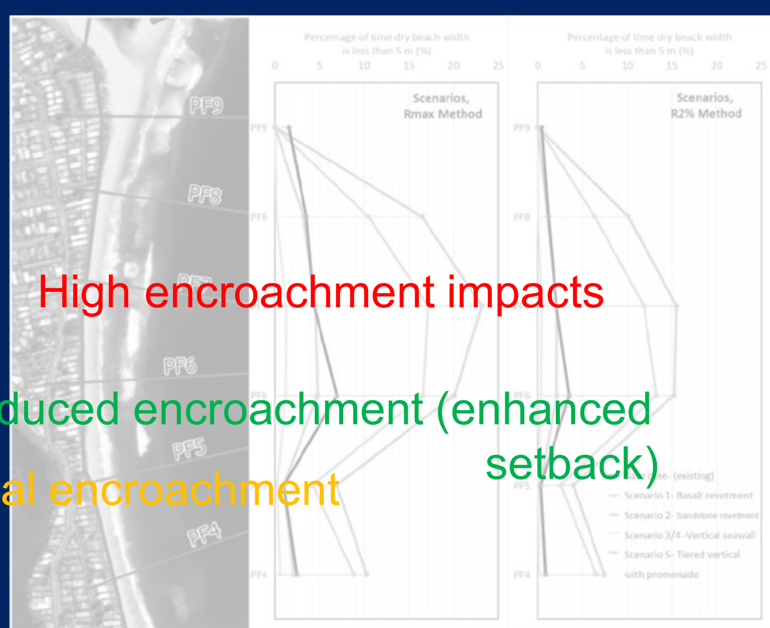

High encroachment impacts

Reduced encroachment (enhanced setback)

Minimal encroachment

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Assessing seawall impacts on beach amenity

Surf amenity Impacts

- 91 seawall structures on sandy beaches were catalogued, predominantly in south-east Queensland and NSW. Catalogued criteria
  - Status as a World/National Surfing Reserve;
  - Prevalence of major surfing contests (regional, state, national, international)
  - Prevalence of recreational surfing
  - Prevalence of surf life saving activities
  - Prevalence of beach tourism
  - Publicised issues, particularly regarding beach amenity or surfing impacts

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Assessing seawall impacts on beach amenity

Surf amenity Impacts

- 91 seawall structures catalogued for surfing activity and publicised adverse amenity impacts
- Up to 7 have known adverse publicity regarding impacts on beach amenity: Belongil, Brooms Head, Stockton, Collaroy-Narrabeen, Warilla Beach, Caseys Beach, Malibu (California).
- Common features:
  - Alignment more seaward (alongshore access issues)
  - Often high underlying recession rates
  - Entry and exit hazards to/from the water

➢ Proposed seawalls at Wamberal unlikely to adversely impact in surf quality, undertaken in deeper waters.

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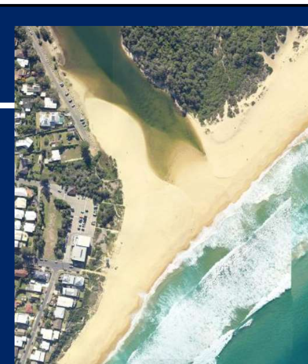
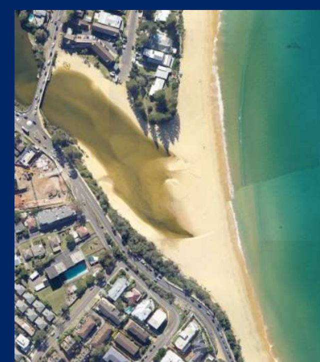
Assessing seawall impacts on beach amenity

End Erosion Impacts

- Lagoon to lagoon structure
- Difficult to quantify by conventional means > end regions influenced by lagoon entrance processes, bridge abutments and rocky foreshores.
- Unlikely to affect other developed areas along the beach.
- Specifications of termination subject to detailed design.





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Assessing seawall impacts on beach amenity

Other amenity Impacts

- Post-storm ad-hoc protection debris
  - Opportunity – Existing ad-hoc material removed during seawall construction
- Visual amenity/safety
  - Vertical walls - Large vertical relief visually imposing/safety concern where not buried
  - “Fitting in” with backshore topography
  - Benefit of tiered structure
- Foreshore access
  - Promenade: enhanced alongshore access before and after storms.

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Assessing seawall impacts on beach amenity

Seawall Concept Option	Percentage of time with less than 5 m available dry beach width (%) [a]	Encroachment into active beach and cross-shore impact	Available dry beach width impact	End erosion impact	Surf amenity impact	Post-storm ad-hoc protection debris on beach	Visual amenity impacts	Foreshore access impacts	Safety impacts	Overall beach amenity impact assessment
Existing beach (including present ad-hoc rock protection)	*1.4% to 3.3%*	*Average of ~5 to 12 days per year when beach is less than 5 m. Higher encroachment of ad-hoc protection in central region of beach.*	*Infrequent disruptions following major storms with narrow beach conditions.*	*Potential end effects at gaps in ad-hoc protection.*	*No adverse impacts identified.*	*Emergency works 1974 to present, rock rubble fill, brickwork, concrete, rubber tyres, old septic tanks, failed timber structures, etc. Exposed and dislodged with storms.*	*Poor after storms when existing ad-hoc material exposed. Large unstable dune scarp.*	*Alongshore access inhibited after storms with large unstable dune scarp at access points.*	*Dangerous narrow beach conditions and access points after storms. Risks trying to traverse ad-hoc protection encroaching into shoreline. Large unstable dune scarp.*	*As present – undesirable conditions particularly after storms*
Impacts relative to existing beach amenity										
Option 1: Basalt Rock Revetment	6.8% to 9.5%	Adverse – Average of 24 to 34 days per year when beach is less than 5 m. Higher encroachment	Adverse – More frequent conditions with narrow beach	Potential for minor added erosion when end of seawall is exposed to waves [b]	No adverse impact expected	Beneficial – Existing ad-hoc material removed during seawall construction	Moderate – Presence of large rock structure where not buried [d]	Adverse – Alongshore access inhibited more frequently	Moderate – safety risks at narrow beach sections	Moderate to high adverse impact
Option 2: Sandstone Rock Revetment	8.7% to 12.8%	Adverse – Average of 32 to 47 days per year when beach is less than 5 m Higher encroachment.								Moderate to high adverse impact
Option 3: Vertical Seawall	0.2% to 0.6%	Beneficial – Average of 1 to 2 days per year when beach is less than 5 m. Reduced encroachment	Beneficial – Reduction in conditions with narrow beach	Minimal end effects expected due to landward alignment [b]			Moderate – Large vertical relief visually imposing where not buried [d]	Beneficial – wider beach to improve alongshore access	Moderate – safety risks associated with vertical relief [d]	Low to beneficial impact
Option 4: Vertical Seawall with Rock Toe:	0.2% to 0.6%	Beneficial – Average of 1 to 2 days per year when beach is less than 5 m Reduced encroachment								Low to beneficial impact
Option 5: Tiered Vertical Seawall with Promenade	1.1% to 2.6%	Slightly Beneficial – Average of 4 to 9 days per year when beach is less than 5 m Reduced encroachment	Beneficial – Slight reduction in conditions with narrow beach + provision of promenade access				Beneficial – reduced vertical relief + opportunities for enhanced foreshore landscaping [d, e]	Beneficial – slightly wider beach to improve alongshore access + provision of promenade access	Beneficial – safer alongshore access after storms + reduced vertical relief. [d]	Low to beneficial impact[f]

[a] Values defined by R2% (the wave runup exceeded by 2% of waves) and Rmax (the maximum estimated wave runup) and averaged along the length of the beach between lagoon entrances.
[b] Region of potential end effects are also influenced by lagoon entrance processes, bridge abutments and rocky foreshores. Potential end effects are unlikely to affect other developed areas along the beach. Specifications of termination design at lagoon ends are subject to detailed design.
[c] Does not consider other sources of debris from eroded vegetated dunes and lagoon entrances.
[d] Concept design crest levels to be refined during detailed design. Visual and safety amenity will benefit from removal of ad-hoc protection and unstable dune scarps.
[e] Design considerations to mitigate privacy impacts on beachfront residents are addressed in the *Stage 3 Seawall Concept Design Options (MHL2780, 2021).*
[f] Also provides broader public amenity value of foreshore promenade.

Overall amenity impact assessment of seawall options:

- Rock Revetment: Moderate to High
- Vertical Seawalls: Low (vertical relief issues)
- Tiered seawall with promenade: Low + added foreshore promenade amenity

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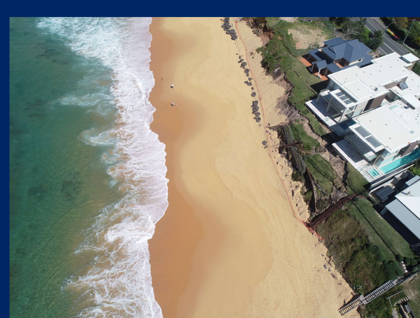
Sand nourishment for beach amenity

- Volume Requirements to maintain present day sandy beach amenity:
  a) Offsetting seawall encroachment (Rock Revetment Options Only, Upfront)
    Lagoon to lagoon: 250,000 to 270,000 m³
    Lagoon to lagoon + Terrigal: 490,000 to 530,000 m³
  b) Design recession maintenance. SLR + underlying. (All Options, every 10 years)
    Lagoon to lagoon: 80,000 m³
    Lagoon to lagoon + Terrigal: 140,000 m³



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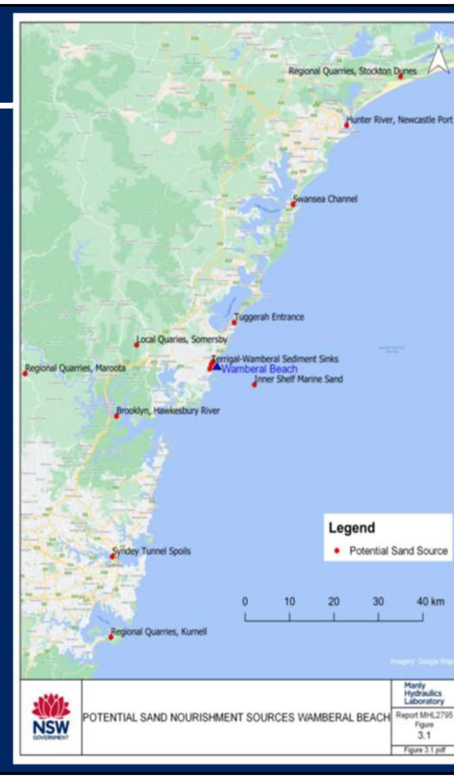
Sand nourishment for beach amenity

- Potential sand sources:
  - Local and regional quarries
  - Lagoon entrances
  - Active foredune management
  - Port and navigation dredging
  - Offshore dredging
  - Metro tunnel spoils



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Sand nourishment for beach amenity

Overall sand nourishment assessment:

- Number of feasible sources however few of these offer sufficient capacity for upfront nourishment requirements in excess of around 50,000 m^3.
  - *Larger volume sources subject to future viability and availability at the time of works.*

- Seawalls with lower encroachment impacts considered beneficial (lower upfront nourishment requirements)

Location	Total Resource Available	Estimated Overfill Factor *	Indicative unit cost ($/m³)	Constraints / Comments	Recommendation
Local Quarries - Grants Rd Sand	~50,000 m³/y	1.3	50	• Supply limited due to high regional construction industry demand and limited resource availability • Volume requires supplementing from other sources	Further investigation recommended.
Regional Quarries - Stockton	~200,000 m³/y	2 - 3	>100	• High cost due to haulage • Supply limited due to high regional construction industry demand and limited resource availability	Not recommended. (high cost)
Wamberal and Terrigal Lagoon Entrance	43,000 m³ (20,000 at Terrigal and 23,000 at Wamberal)	1	20 - 40	• Requires repeat entrance clearance program to maintain. • Volume requires supplementing from other sources • Maintains transfer of sand within Terrigal-Wamberal sediment compartment (i.e. beach replenishment) • Variable volumes and sediment quality dependent on dredge campaign. • Impacts on recreational area and amenity at entrances	Further investigation recommended.
Active foredune management	25,000 m³	1.5 - 3	15 - 30	• Requires repeat foredune maintenance program • Disturbances to foredune ecology in Wamberal Lagoon Nature Reserve • Volume requires supplementing from other sources • Maintains transfer of sand within Terrigal-Wamberal sediment compartment (i.e. beach replenishment)	Subject to detailed EIA in consultation with NPWS.
Hunter River (South and North Arm)	Several million m³	Unknown. Fine to medium grained sand	60 - 120	• High cost due to haulage • Potentially cheaper if undertaken as part of broader regional nourishment program	Subject to future viability. (potential high cost due to haulage)
Brooklyn, Hawkesbury River	100,000 m³	Unknown. Fine to medium grained sand	23 - 43	• Potentially cheaper if undertaken as part of broader regional nourishment program	Not recommended. (sand required in source compartment)
Swansea Channel	10,000 - 50,000 m³ every 1-5 years with infrequent major dredging	2	45 – 80	• Likely exhausted by local sand requirements closer to the source	Not recommended. (sand required in source compartment)
Tuggerah Entrance	30,000 -80,000 m³/y every 1-2 years	Unknown. Fine to medium grained sand	40 - 60	• Likely exhausted by local sand requirements closer to the source	Not recommended. (sand required in source compartment)
Offshore dredging	Order of 10 million m³	1 – 1.5	10 - 30	• Environmental concerns of Government and community • Potentially cheaper costs (<$10/m3) if undertaken as part of a broader regional nourishment campaign	Subject to future viability. Further investigation recommended.
Sydney tunnel spoils	Several million m³	Unknown	<10	• Low cost option • Sand compatibility of spoils for nourishment purposes requires further investigation	Subject to future viability. Further investigation recommended.

* Factor applied to design volume to account for additional nourishment due to finer borrow sand grain size composition than that of native beach.

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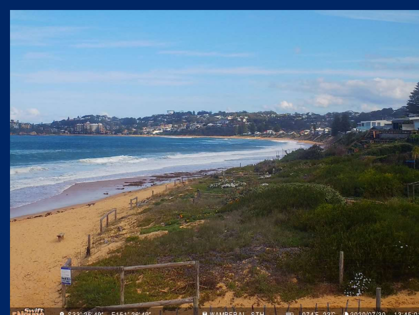
Wamberal Beach Real-time Coastal Monitoring

Coastal Monitoring Initiatives

- Trailcam installed & operating at Wamberal SLSC (WRL)
- CoastSnap station installed at Terrigal Dr (WRL)
- Fixed Lidar station installed & operating (24/7)
- ➢ Live Coastal Monitoring Webpage: live beach conditions (beach width, berm height, subaerial beach volume, wave runup, nearshore waves, coastal imaging)



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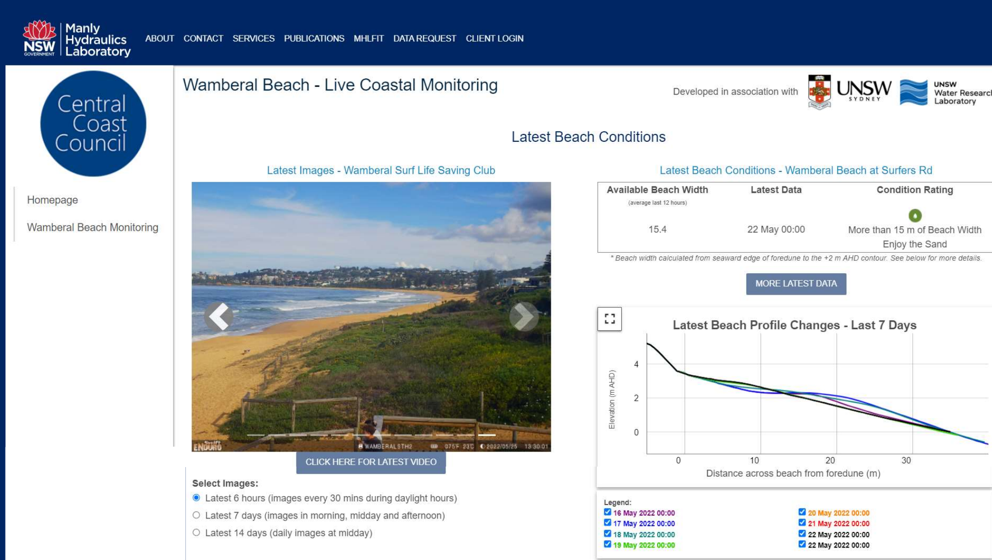
Wamberal Beach Real-time Coastal Monitoring

https://mhlfit.net/users/CentralCoast-WamberalBeach



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Wamberal Beach Real-time Coastal Monitoring

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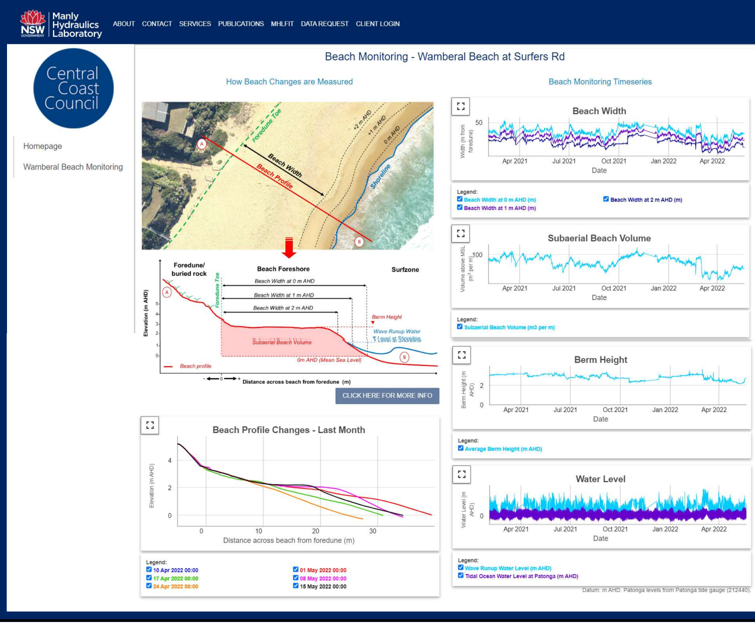

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Wamberal Beach Real-time Coastal Monitoring

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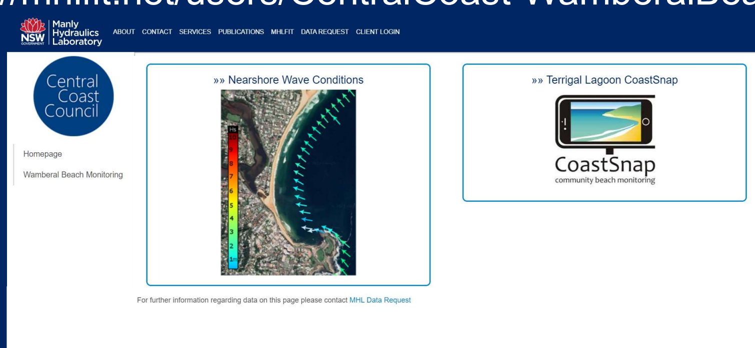

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Summary

- ✓ Seawall concept design options for Wamberal Beach
- ✓ Amenity impact assessment of options
- ✓ Sand nourishment investigation
- ✓ Cost-benefit analysis

- ➢ Seawall and sandy beaches can coexist with considered design that seeks to preserve (or enhance) beach amenity while protecting against the hazard.

Beach amenity impacts are to be evaluated throughout all phases of a seawall design from concept to construction to decommission.

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Next Steps

Council's key criteria derived following review of technical reports, community consultation and Council's role in coastal management:

- located as far landward;
- located wholly on private property where possible;
- constructed, owned, and maintained by property owners;
- narrowest footprint;
- least sand nourishment requirements;

Currently in development:

- Minimum engineering design guidelines to help in DA assessment and inform detailed design

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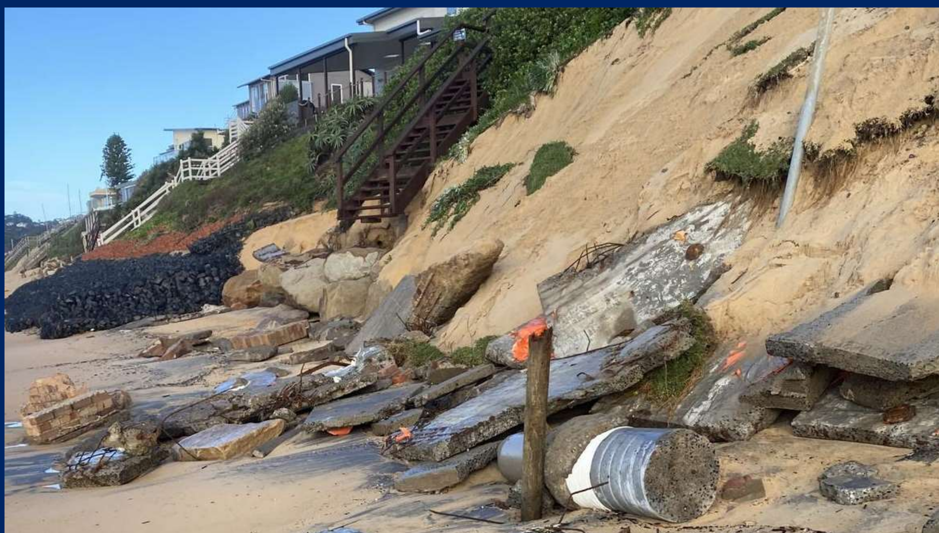
Opportunity



Providing a long-term, holistic solution for Wamberal Beach that enhances and preserves the sandy beach environment and public amenity while also managing coastal hazard risks to people and property.

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