TETRA TECH COFFEY

Part 1 of 2: Report body and Appendices A and B

Land Capability – Geotechnical Factors

Request for Planning Proposal: Kurnell Planning Proposal – 251, 260R, 278, and 280-282 Captain Cook Drive, Kurnell

Besmaw Pty Ltd

Reference: SYDEN211738-1 R01

30 November 2023

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PREPARED FOR

Besmaw Pty Ltd
PO Box 1630
North Sydney 2059

ABN 67 008 481 187
Contact: Duncan McComb
Email: dmccomb@besmaw.com.au

PREPARED BY

Tetra Tech Coffey
Level 20, Tower B, Citadel Towers
799 Pacific Highway
Chatswood NSW 2067

p: +61 2 9406 1000
ABN 55 139 460 521

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1. INTRODUCTION

1.1 BACKGROUND

This Land Capability – Geotechnical Factors report has been prepared by Tetra Tech Coffey to accompany a proponent initiated Planning Proposal (Planning Proposal) in support of the proposed amendment to State Environmental Planning Policy (Precincts—Central River City) 2021 (SEPP Precincts) and Sutherland Shire Local Environmental Plan 2015 (SSLEP 2015).

The Planning Proposal aims to translate and amend current land uses zones under the applicable controls to be consistent with the standard instrument local environmental plan zones and enable additional uses to accommodate a diverse range of land uses at 251, 260R, 278, and 280-282 Captain Cook Drive, Kurnell (the site). The Planning Proposal will establish a new mixed-use community encompassing residential, employment, tourism, education, cultural facilities, ecological regenerative zones and public open space areas.

This report has been prepared to assess geotechnical factors associated with the proposed development following the TIA study that was undertaken in February 2020.

In March 2023 the proponent submitted a Scoping Proposal to Sutherland Shire Council to commence the formal Planning Proposal process, in accordance with the LEP Making Guidelines. The Scoping Proposal provided a comprehensive ‘status update,’ outlining the concept master plan, the intended development outcome, the proposed planning controls and the environmental considerations which were to be further resolved.

As part of the Scoping Proposal process, Council referred the Scoping Proposal package to the NSW Department of Planning and Environment (DPE), State agencies, and several internal Council teams for review and comment. The advice received from these stakeholders has provided clear directives on the necessary updates and key focus areas within the technical documentation.

Separate to the Scoping Proposal package, extensive and ongoing engagement with relevant State Agencies has occurred since November 2022, with the objective of clarifying and resolving any of the outstanding considerations.

Besmaw has engaged Tetra Tech Coffey to prepare a Geotechnical Factors Report to address the feedback received from the DPE and state agencies and reflects the engagement undertaken to date. Tetra Tech Coffey was not invited to meet with representatives of State agencies or Council on this scope.

1.2 SCOPE OF STUDY

To facilitate the proponent initiated Planning Proposal (Planning Proposal) in support of the proposed amendment to the State Environmental Planning Policy (Precincts—Central River City) 2021 (SEPP Precincts) and the Sutherland Shire Local Environmental Plan 2015 (SSLEP 2015), a range of technical studies have been prepared to provide evidence-based planning in accordance with the 'scope of works' and the technical methodologies endorsed by the PWG on 25 July 2019.

In May 2023 a scooping proposal was submitted to Sutherland Shire Council to provide a ‘status update’ and outline the concept master plan for which a supporting suite of technical documents that were submitted with the SEPP Amendment would be updated.

As part of the Scoping Proposal process, the Council issued the Scoping Proposal and supporting documentation to the DPE, State agencies, and several internal Council teams for review and comment. The advice received from DPE provided clear directives for updating and addressing key matters in the technical documentation.

Besmaw has engaged Tetra Tech Coffey Pty Ltd (Tetra Tech) to prepare a desk-top geotechnical study to address the original DPE scope of works and address the matters raised in the subsequent feedback received from the DPE, State agencies including legislative and regulatory requirements.

The desk-top study presented in this document draws upon Tetra Tech's experience and settlement monitoring data collected over more than a decade as part of the geotechnical capacity improvement of imported fill materials used in the rehabilitation of the quarry void and addresses the comments on geotechnical factors for the site received following the review of the scoping proposal.

The desk-top study addresses the following aspects nominated by DPE:

- identify and map soil landscapes within the site and the limitations of the land including erosion and sedimentation hazards, and shrink swell hazards (volume expansion) – Section 4.3;
- assess slope stability across the site, identifying areas which are, or are likely to be, prone to stability problems – Section 6.1;
- avoid significant adverse environmental impacts from the use of land that has a probability of containing acid sulfate soils and related groundwater – Sections 4.4 and 4.5;.
- based on the above factors, map the capability of the land for future urban development – Section 7.4;
- provide recommendations on slope stability which recognise the range of potential land uses on the site, including conservation land, accessible open space, residential development and employment uses – Section 6.1; and
- investigate the rehabilitation and construction of land following sand mining, including the structural stability and soil compaction of landforms, and demonstrate that a stable platform exists (or will exist) for the proposed forms of urban development – Section 7.4.

A copy of DPE feedback and advice on Kurnell Scoping Proposal of 10 August 2023 as relevant to Land Capability – Geotechnical Factors is included in Appendix D to this report. The findings of this report have informed the master planning process for the site.

1.3 THE SITE

- The site consists of four property titles of which three titles are south of Captain Cook Drive which is the arterial road for the Kurnell Peninsula. The site location is shown on Figure 1-1 (following page), is irregular in shape, covering an area of approximately 210.5 ha and is defined as:
- 251 Captain Cook Drive, Kurnell Peninsula, being Lot 2 in DP1030269 (Lot 2 North – 16 ha),
- 260R Captain Cook Drive, being Lot 9 in DP586986 (referred to as Lot 9 – 82m^2)
- 278 Captain Cook Drive, being Lot 8 in DP586986 (Lot 8 – 34.5 ha), and
- 280-282 Captain Cook Drive, being Lot 2 in DP559922 (Lot 2 South – 160 ha).

Figure 1-1 Locality Map

2. OBJECTIVE

For Lot 2 South, the objective of this geotechnical assessment is to investigate the rehabilitation and construction of land following sand mining, including the structural stability and soil compaction of landforms and to demonstrate that a stable platform exists (or will exist) for the proposed forms of urban development.

For Lot 2 North and Lots 8 and 9, the objective is to assess the geotechnical suitability of the future condition of the “unmined” part of the site for the proposed urban development, including compatibility with expected occurrence of groundwater and acid sulfate soils.

This report presents the results of desk-top geotechnical site assessment carried out by Tetra Tech Coffey to meet these objectives.

3. PROPOSED DEVELOPMENT

3.1 CURRENT SITE ACTIVITY

The site is located on the Kurnell Peninsula in Sutherland Shire Local Government Area. Lot 2 North is currently operating as horse stables and riding school. Lots 8 and 9 are vacant and comprise remnants of natural sand dunes and degraded native vegetation. Lot 9 was previously used as the position of an aircraft navigation beacon which has been removed.

Lot 2 South currently operates under two separate Environmental Protection Licences (EPLs) issued by the NSW Environmental Protection Agency (EPA) for sand extraction (EPL 3629) and land rehabilitation (EPL 5658). Sand extraction has occurred on Lot 2 South since 1968 when the State Planning Authority granted approval. Rehabilitation of the quarry void is undertaken using imported Virgin Excavated Natural Material

(VENM) which is controlled through an Environmental Management Plan (EMP) and associated Standard Operating Procedures.

3.2 PROPOSED URBAN DEVELOPMENT

The Planning Proposal aims to translate and amend current land uses zones under the applicable controls to be consistent with the standard instrument local environmental plan zones and enable additional uses to accommodate a diverse range of land uses at 251, 260R, 278, and 280-282 Captain Cook Drive, Kurnell.

The Planning Proposal will establish a new mixed-use community encompassing residential, employment, tourism, education, cultural facilities, ecological regenerative zones and public open space areas. In support of the Planning Proposal, a Master Plan has been prepared by Group GSA which demonstrates the potential future urban form for the site.

For this geotechnical study, relevant elements of the Master Plan for the site are included as Appendix B. The information in Appendix B is presented as a series of site plans prepared for Besmaw by Group GSA relating to:

- Land use and area allocation showing five areas within the site: Quibray Bay Precinct in Lot 2 North, Town Centre North and Town Centre South in the western part of Lot 2 South, Bate Bay Precinct in the central part of Lot 2 South with a minor extension into the adjacent Lot 8, and Boat Harbour Precinct in the eastern part of Lot 2 South.
- Building height distribution for each precinct, which ranges from 2 to 12 storey buildings south of Captain Cook Drive and is an important geotechnical factor in management of rehabilitation of Lot 2 South. Quibray Bay Precinct has buildings from 2 to 6 storeys proposed.
- The proposed ground surface levels adjacent to buildings is between 4 and 8 metres (Australian Height Datum).

The Landscape framework includes a pedestrian (only) bridge (an ecobridge) over Captain Cook Drive on the western side of the site. Unlike other landscaping elements proposed, geotechnical design will be required for bridge supports. An extract from the Master Plan illustrating the ecobridge is included in Appendix B for reference.

This geotechnical desk-top study assesses the suitability of the Master Plan as a reference for future urban development.

4. ENVIRONMENTAL SETTING

4.1 TOPOGRAPHY AND DRAINAGE

Topography and drainage of Lot 2 North includes:

- The current site condition of Lot 2 North is mostly flat grassed land with a surface level of 1 m to 2 m AHD (based on survey plan issued by CEH Consulting, reference KUR-MGA-PLAN For DA, dated 10/11/2023), and elevation lowers towards the north. Natural sand is present in the horse arena and around the stables. Dense vegetation (not native) is present within the south-eastern portion of Lot 2 North, which is a tidally influenced wetland area.
- Surface water is expected to infiltrate directly into the unsealed sandy ground even during intense rainfall due to the low elevation and low relief of Lot 2 North. Groundwater is reasonably expected to flow towards Quibray Bay.

Topography and drainage of Lots 8 and 9 includes:

- The current site condition of Lot 8 is mostly vegetated by a mixture of native and introduced shrubs with two remnant sand dunes up to 10m and 12m AHD in the northern part and up to 14m AHD in the

southern part of the lot and low areas (3m AHD) in the northwest and southeast corners (based on survey plan cited above).

- The surface of Lot 9 is at approximately 5m AHD and is on the northern face of a remnant sand dune which occupies most of the southern part of Lot 8.
- Surface water on Lots 8 and 9 is expected to infiltrate directly into the unsealed sandy ground even during intense rainfall and the groundwater table may rise to the ground surface in low areas to the northwest and southeast during periods of higher rainfall. Groundwater beneath Lots 8 and 9 is reasonably expected to flow north to northwest towards Quibray Bay after future rehabilitation of the quarry void because of the continuity of the sand aquifer in that direction.

Topography and drainage of Lot 2 South includes:

- The current site condition consists of a large void created by sand extraction which is progressively occurring in the south-eastern portion of the site. Surface elevations of natural ground around the perimeter of Lot 2 South range from about 5 m Australian Height Datum (AHD) adjacent to Captain Cook Drive in the north to 5 to 10 m AHD along the crest of the foreshore dunes in the south and along the access road to Boat Harbour. Rehabilitation of land within the western portion of the site is ongoing and is progressing to the southeast.
- Rainfall onto the surface of Lot 2 South currently drains into the dredge pond, infiltrates into exposed surface soils or falls directly on the dredge pond. Groundwater currently flows mostly south towards Bate Bay and Boat Harbour due to the shorter distance between the dredge pond and Bate Bay (compared with the much longer seepage pathway to Quibray Bay to the north).

Proposed topography and drainage for the Master Plan is included in Appendix B. This plan indicates generally flat topography in Lot 2 North with the surface of the development area raised to mitigate flood risk with drainage radially to the edges of the raised area. The development area on Lot 2 South is proposed to have a gentle slope from south (8m AHD) to north (4m AHD) with drainage directed to stormwater detention basins formed by natural low areas in the southeast and northwest of Lot 8. These areas are reasonably expected to promote groundwater recharge through the sandy aquifer which is continuous beneath Lot 8 and Lot 2 North and continues as the sand in Quibray Bay.

4.2 SURFACE WATERS AND WETLANDS

The closest natural surface water bodies are Bate Bay and Boat Harbour (Tasman Sea) located immediately south of Lot 2 South and Quibray Bay which joins Botany Bay located north of Lot 2 North. The current dredge pond occupies the southern part of Lot 2 South. The base of the dredge pond is typically -12 m AHD and water level in the dredge pond is approximately 1 m AHD, with mean sea level being 0 m AHD (established using 1966-1968 observations around Australia). Ephemeral wetland areas may occur during periods of high rainfall in the southeast and northwest corners of Lot 8.

4.3 GEOLOGY AND SOIL LANDSCAPES

NSW Geological Survey indicates the locality is underlain by Holocene marine deposits including:

- Qhbr – Marine quartz sand, minor shell content, interdune (swale) silt and fine sand.
- Qmd – Marine quartz sand.
- Qbd – medium to fine marine quartz sand with podsols.

The Soil Landscapes of the Wollongong and Port Hacking 1:100,000 Sheet report (Chapman G.A. and Murphy C.L., 1989), produced by Department of Conservation and Land Management, Sydney, indicate the site is underlain by the Wollongong soil landscape (wg) which typically comprises beaches / coastal fore-dunes of Quaternary Wind-Blown Sands. Soils are typically deep (greater than 2 m) calcareous sands on beaches, siliceous sands on fore-dunes and isolated humic podsols in swales. Limitations include extreme

wind erosion hazard, high permeability soils, very low fertility with localised flooding and permanently high water tables.

Site soils are underlain by Hawkesbury Sandstone. This sandstone is the most common rock formation encountered within the Sydney area, and it defines most of the eastern coastal topography (rocky, cliff headlands between alluvial creeks and estuary mouths). The Hawkesbury Formation is over 250m thick, and the sandstone is typically medium to coarse grained, quartz sandstone with subordinate, discontinuous shale beds of varying thickness. The sandstone layers are up to 3 m thick, and occur as massively bedded or cross-bedded units. It is an excellent foundation material and supports numerous tall buildings in the Sydney CBD.

Lot 2 South has been used for sand extraction since 1968, with the south-eastern corner of the site to be quarried in the future. Sand extraction occurs to a level of -12 m AHD, which is 17 m below the surface level at Captain Cook Drive. Backfilling of the excavation is being undertaken using imported VENM which will be the underlying geology in this area following rehabilitation. A buffer zone up to 25 m width has been retained around the boundary of Lot 2 South where natural sands are not mined with a 125 m set back area along the southern boundary of the site adjoining Bate Bay. Figure 2 shows the current area of sand extraction and future quarry area.

Reference to historical aerial photographs confirmed that Lot 2 North and Lot 8 have not been quarried for sand. Thus, this part of the site comprises predominantly natural soils and geology with minor introduced fill around buildings to provide a trafficable surface. A series of aerial photographs indicating progressive expansion of the quarry and subsequent rehabilitation of the site is provided in Appendix C.

Surface soils were sampled across Lot 2 North and Lot 2 South in 2018 as part of a Preliminary Salinity Assessment undertaken concurrently by Tetra Tech (then trading as Coffey) and reported separately. Soil type and description was recorded at each sampling location by an experienced Environmental Scientist, in general the following soils were encountered:

- Lot 2 North: The surface soils were described as topsoil consisting of silty sand and sand, light brown to dark brown with inclusions of organic material, dead grass, mulch, sea shells, trace fine gravels in places. No odours or staining indicative of possible contamination were observed. This description is consistent with the natural soils expected at the site.
- Lots 8 and 9: areas comprise natural sands which have not been subject to sand extraction or backfilling. These wind-blown deposits were described as; silty sand / sand, light brown to dark brown, fine to medium grained, with inclusions of sea shells, some dead roots and grass in places, no odour or staining observed. This description is consistent with the natural soils expected at the site. Natural sands dominating the surface of Lot 8 and 9 are expected to be consistent with this description.
- Lot 2 South: area where sand extraction and backfilling has occurred; fill has the consistency of gravelly clay, silty clay and gravelly sand, medium plasticity clays, trace gravels, cobbles and boulders, no odours or staining observed. The origin of fill materials is from hundreds to thousands of locations throughout the greater Sydney area. Natural soils and rocks, meeting the description of Virgin Excavated Natural Material (VENM), is typically derived from weathered Hawkesbury sandstone and shales which dominate the sedimentary geology of the Sydney Basin (NSW Government: Surface geology of New South Wales; 1:3,000,000 map).

Soil landscapes for the site are mapped in Figure 4-1 (following page). For the purpose of this illustration, Lot 9 is effectively included as a “dot” on the Lot 8 boundary.

Figure 4-1 Soil landscapes for Lot 2 North, Lots 8 and 9 and Lot 2 South

Note: Dredge pond rehabilitation is dated July 2017, and has since advanced further east.

A Soil Salinity Assessment relevant to soils to be retained for future development has been reported by Tetra Tech (Coffey reference SYDEN211738-R02, dated 30 May 2018, in a series of technical studies commissioned by Besmaw).

Tetra Tech interpreted results of direct soil sampling and analysis in the context of soil salinity, and concluded that:

- Lot 2 North appears to have minimal potential for constraints on landscaping attributable to soil salinity.
- On Lot 2 South sands that will remain appear to have a moderate potential for constraints on landscaping due to soil salinity, however these sands are supporting healthy native plant species in the revegetation program operated by Besmaw.
- On Lot 2 South Fill, imported VENM had general potential for low to moderate saline conditions, with some occurrence of isolated areas of higher salinity.
- The spatial distribution of results across the surface of imported fill indicates that salinity potential may decrease with weathering over several years so that the land at the development stage is likely to have a lower occurrence of more than moderate salinity.
- Stormwater infiltration, as an element of WSUD, should not be adversely affected by salinity of VENM.
- Considering results for electrical conductivity, a conservative assumption of moderate aggressivity for design of deeper foundations is recommended.

Given the similar origin of natural sands on Lots 8 and 9 to natural sands on Lot 2 South, we reasonably expect a similar conclusion regarding salinity.

4.4 ACID SULFATE SOILS

Tetra Tech's reference to Acid Sulfate Soil Map Sheet ASS_007 in the Sutherland Shire Local Environment Plan (LEP) 2015 identified the area of Lots 8 and 9 were classified as having potential acid sulfate soil (ASS) risk. Lot 2 North and Lot 2 South were not assigned a ASS risk.

A high proportion of natural soil on Lot 2 South has or will be removed by sand quarrying under controls of EPL 5658. Thus, the ASS risk related to these soil does not affect the future development of the site. Figure 4-1 indicates the planned extent of quarrying.

The geological origin of near-surface (say top 3m) soil on Lot 2 North and remaining natural soil around the perimeter of Lot 2 South is wind-blown (aeolian) marine sand transported from the eastern end of Bate Bay. Aerial photographs taken in the 1950s and 1960s show this process in current (geological) times. Similar mobile sand dunes occurred on Lot 8 (south of Lot 2 North) and also to the west of Lot 2 North, and also on Lot 2 South and the Breen land.

Given this known depositional landscape for shallow soil, the ASS class on Lot 2 North is reasonably expected to be a combination of 3 and 4, with possible 2b in the environmental reserve land on the eastern side of Lot 2 North. Similarly for Lot 2 South, natural soil along the western boundary is expected to have ASS class 3 or 4, with Class 2 in historical inter-swale marshy areas. Lots 8 and 9 are assigned ASS Class 3 to 4.

Potential acidification of ASS occurs when soils from below the water table are exposed to air during excavation, or are exposed to air when construction dewatering is required. When a specific future development is proposed, then the presence of ASS should be assessed, and development consent obtained according to the identified class of ASS specific to the proposed construction site. For the ASS classes associated with the site from reference to Sheet ASS_007, the conditions requiring development consent are:

- Class 2 – Works below the natural ground surface, and works which are likely to lower the water table
- Class 3 - Works more than 1 metre below the natural ground surface, and works which are likely to lower the water table by more than 1 metre
- Class 4 - Works more than 2 metres below the natural ground surface, and works which are likely to lower the water table by more than 2 metres

Recent soil contamination assessment in unmined areas on Lot 2 North and Lot 2 South did not include testing for acid sulfate soils.

Land rehabilitation operations on Lot 2 South may receive Potential Acid Sulfate Soils (PASS) in accordance with Special Conditions in the EPL 5658. The EPL requires that any PASS material must be delivered to the site within 24 hrs of excavation to avoid oxidation, placed at least one metre below the water table (in the dredge pond) and have a pH of not less than 5.5 when delivered. Tetra Tech considers that PASS accepted at the site in compliance with Special Conditions of EPL 5658 poses a low risk of acidification because PASS is placed directly into the southern end of the dredge pond and below water level within 24 hours of excavation at the source site. Tetra Tech also notes that the inclusion of PASS presents a low environmental risk because the quantity of PASS accepted is a small fraction of the total imported quantity (approximately 0.8% based on Besmaw records for the period 1 February 2018 to 31 January 2019) and the PASS placement area will be covered by at least 10 m of VENM fill for the future landform.

4.5 HYDROGEOLOGY

A groundwater assessment was undertaken as part of the Kurnell Sand Extraction proposal by Rocla Pty Limited in 2004 (Rocla, 2004) which aimed at locating the potential impacts of sand extraction and dredging on the groundwater regime. The hydrogeological regime described in Rocla, 2004 is summarised below.

Prior to sand mining, groundwater occurred at shallow depths beneath Lot 2 South (0.5 to 3.5 m below ground level) and formed a mound beneath the more elevated parts near the centre of Kurnell Peninsula, with flow north towards Quibray Bay through Lot 2 North and to the south towards Bate Bay within Lot 2 South.

Rainfall can result in changes to groundwater level which may range between 0.7 m AHD and more over short intervals and 1.3 m AHD and more over longer periods. The potential sources of aquifer recharge are rainfall and surface run off from local catchment areas.

Underlying sands have moderate hydraulic conductivity typically ranging between 5 and 50 m/day at shallow depths and 1 to 10 m/day at depths close to the Hawkesbury sandstone lying at -3 to -24 m AHD. Depth to bedrock generally increases from east to west across the site. The aquifer within the underlying sands at the site is unconfined and is exposed within the dredge pond.

A desk study of current and future groundwater flow has been reported by Tetra Tech (Coffey reference SYDEN211738-R06, dated 26 February 2020, in a series of technical studies commissioned by Besmaw).

5. SITE HISTORY RELEVANT TO GEOTECHNICAL FACTORS

5.1 LOT 2 NORTH AND LOTS 8 AND 9

Tetra Tech confirms that Lot 2 North and Lots 8 and 9 are outside of the area licensed by NSW EPA for sand quarrying activity (that is, Lot 2 South). Structures on Lot 2 North and the southwest corner of Lot 8 comprise 2 to 6 storey buildings. Lot 9 is a very small area which is located on the edge of Lot 8 and is not affected by proposed development. Construction of two storey buildings is expected to use light-weight building materials (such as timber frames, steel cladding) which generally are not sensitive to settlement. Taller buildings would be supported by larger footings (pad or strip) or by raft foundations above a layer of engineered fill to manage potential differential settlement.

The natural elevation of the ground surface in Lot 2 North is mostly between 2 m and 5 m AHD, and mitigation of flood impact requires the ground floor of future buildings on Lot 2 North to be at 3.5 mAHD (or above). The proposed surface level around buildings proposed for Lot 8 (at the northern end of the Bate Bay Precinct) is between 4m and 6m AHD and does not require additional fill for flood mitigation. Thus, foundations for buildings above 2 storeys may require replacement of a layer of sand with engineered fill material to adequately support reinforced concrete footings. Relevant details would be determined in geotechnical design of structural support for individual buildings.

The ecobridge over Captain Cook Drive is outside the area of quarrying activity and footings for the ecobridge have similar design requirements to taller buildings proposed for the Quibray Bay Precinct.

The formation of Lot 2 North and Lot 8 as part of a Wollongong soil landscape of wind-blown sand dunes, and the observed depth of sand on Lot 2 South, indicates that the sandy soil on Lot 2 North and the southern end of Lot 8 has not been subject to any meaningful preloading which could have improved foundation capacity.

5.2 LOT 2 SOUTH

The large majority of Lot 2 South has been disturbed by quarrying sand using a hydraulic dredger. Sand is typically removed to a level of -12 mAHD, which is approximately 17 m below the level of Captain Cook Drive at the northern end of Lot 2 South. Parts of Lot 2 South which have not been quarried include the vehicle compound and site office in the northeast corner, a buffer of sand approximately 25 m wide at the ground surface around the eastern and western perimeters, a 100 m wide buffer south of Captain Cook Drive and a 125 m wide foreshore dune set back along the southern boundary.

Quarrying commenced in the northern end of Lot 2 South and extended towards the southwest and subsequently to the east. A sequence of aerial photographs between 2005 and the present (sourced from Google Earth) is included in Appendix C and illustrates the expansion of the sand quarry. Besmaw has approval for restoration of the void created by sand removal through use of surplus uncontaminated natural soil and rock. The sources of this fill material were a wide variety of construction excavations in the Sydney metropolitan area. Besmaw obtained an Environmental Protection Licence (EPL 5658) as a quality control measure. This imported fill material meets the definition of Virgin Excavated Natural Material (VENM) under the *Protection of the Environment Operations Act 1997*. Progressive rehabilitation of the quarry void is also evident in the aerial photographs included in Appendix C.

6. PRELIMINARY SITE GEOTECHNICAL MODEL AND TREATMENT BY PRELOADING

6.1 MODEL WITH NO PRELOADING

The sand dredging and rehabilitation operation in Lot 2 South creates three zones of materials with different geotechnical characteristics, being:

- An undisturbed sand buffer zone approximately 25 m wide along the eastern and western boundaries, 100 m wide south of Captain Cook Drive and a foreshore set back is 125 m wide adjacent to Bate Bay. This area is expected to have the geotechnical capacity of a layer of loose sand with potential inclusion of peat lenses. Lot 2 North is expected to have a similar geotechnical capacity.
- At transition zone approximately 30m wide from the inner edge of the sand buffer zone where the thickness of sand reduces and is replaced by VENM, with a corresponding transition in geotechnical capacity. This transition is due to the natural angle of repose established after sand extraction.
- A large central zone of VENM ranging from approximately 15 m to 20 m thick which was generally placed into the quarry void by laterally advancing the face of the fill zone by adding VENM from the top of the existing layer. Because the VENM is obtained from hundreds of different source sites, its consistency is a variable mixture of clay, sand, gravel and fragmented rock, typically derived from sandstone or shale. The method of depositing the VENM creates a loose soil with a more variable geotechnical capacity than found in undisturbed natural soil.

Practical civil engineering experience has found that soil materials, such as VENM, having a loose consistency may be subject to substantial settlement on initial flooding by a rapid rise in groundwater level or an abnormally high volume of infiltration of water from the surface. Following rapid flooding or inundation, collapse of the fill matrix may occur in extreme circumstances and is considered to have a very low probability because of the heterogeneity of the fill (many diverse sources in small quantities). Water in the open quarry void is typically at a level between 0 m and 1 m AHD (that is, just above mean sea level). Consequently, VENM above that water level has not experienced initial inundation and may have the potential for excessive settlement post-construction, with or without preloading.

Placement of VENM at Lot 2 South is distinctly different from disposal of waste materials at municipal landfills. The VENM accepted at Lot 2 South has been subject to a control process to exclude unsuitable material and has controlled intake to excavated natural materials which are non-putrescible. Current rehabilitation operations subject the placed material to an engineered pre-consolidation loading to render the site suitable for construction of low-rise residential structures and to reduce the risk of adverse on-going settlement. Typical landfill construction does not provide this level of control on incoming material and does not provide pre-loading to address on-going settlement. VENM is also free of organic matter and organic contaminants which eliminates the potential for bio-degradation and generation of landfill gases (specifically methane, carbon monoxide, carbon dioxide and hydrogen sulfide).

The finished slopes on the final landform in Lot 2 South can be designed to mitigate risks associated with slope stability and erosion using conventional processes. The sandy soils remaining in the buffer zone around the perimeter of the site are not associated with geotechnical risk of instability. Lot 2 North also has stable sandy soil and also has low relief and geotechnical risk of instability is considered to be negligible.

6.2 TREATMENT BY PRELOADING

6.2.1 Behaviour of soil under load

Soil is a collection of solid mineral grains which fit together imperfectly to leave gaps between adjacent grains. In geotechnical engineering, these gaps are referred to as voids. The void ratio of loosely placed soil (similar

to the VENM on Lot 2 South) is typically 20 to 30% of the total volume of the soil. When soil is placed under additional load, the contacts between grains are able to move to adjust to the new load, and this usually results in a reduction in void ratio to provide the required load bearing capacity. Voids are filled with air or water which can flow away from the area where voids are reducing. The volume of the grains does not change, but settlement of the soil surface is observed due to reduction of void space.

Soil is not an elastic material because it does not return to its initial volume when the additional load is removed, as does a tennis ball when hit. The process of reduction in volume of a soil under additional load is called compaction, which is indicated by the upper line to point A in Figure 6-1, with load indicated on the horizontal axis and volume indicated on the vertical axis. When the additional load is removed from soil (the line from A to B), there is usually a small amount of volume recovered, but this is a small fraction of the initial settlement. Application of the same additional load would result in recompression of the small rebound (the line from B to A). However, increase in load beyond the previous total will result in large settlement (the line from A to C).

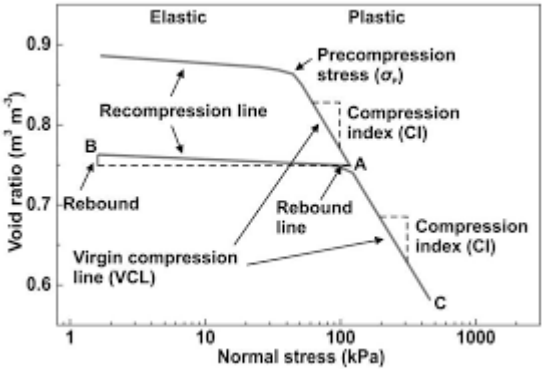


Figure 6-1 Compaction process for soil under load

Time to achieve change in soil volume due to additional load is another factor in behaviour of soil under load. Void space in soil may contain air (unsaturated) or water (saturated). Movement of air through the soil voids is essentially instantaneous due to the low viscosity and high compressibility of air. However, flow of water through voids is time dependent due to the effective incompressibility of water. The parameter describing the flow of water through saturated soil for a unit pressure in water is the hydraulic conductivity. Change in hydraulic conductivity is exponential from sand (reference of 1) to silt (0.001) to clay (0.000001).

Settlement resulting from additional load applied to saturated soil slows exponentially with time. Consequentially, the amount of settlement occurring in the first year after load application will not double until the 10th year.

6.2.2 Preloading design for Lot 2 South

VENM placed in Lot 2 South (described above) is subject to settlement due to its self-weight and any additional loading (surcharge), such as buildings and other improvements. Potential on-going settlement may be managed by increasing the height of the fill platform (the preload) to a level substantially above the proposed future ground level. This provides a surcharge loading on the placed fill which promotes accelerated settlement of the ground to benefit future development of the site within the applied additional load.

Measurements of hydraulic conductivity of the VENM fill applied to Lot 2 South indicate that the rate of settlement in saturated fill is expected to be acceptable because the hydraulic conductivity of the placed fill and natural sands are similar (within a factor of 10). The rate of settlement of the fill is monitored and the elevated surcharge loading is left in place until settlement monitoring results indicate satisfactory long-term settlement performance. Prior to development, the surcharge is removed and a layer of controlled fill is

formed in the footprint of low level structures to provide adequate bearing capacity and to bridge over residual pockets of softer material if present in the underlying fill.

6.2.3 Results from preloading

Preloading guidelines for Lot 2 South were designed by Tetra Tech to provide for construction of low level structures including residential buildings of one or two stories. That is, the additional loading and the time from application of that loading were expected to achieve design limits for future construction of residential buildings of one or two stories.

Tetra Tech's design process included placement and monitoring of VENM fill at selected locations on Lot 2 South to assess the effectiveness of a 3m additional preload and a 4m additional preload for which settlements were intended to be monitored for 3 to 6 months. This trial included a similar monitoring of VENM fill without preload, which was constructed from the base of the dredge pond at -11.5m AHD to a top level of 4m AHD. The preloading trial period was extended to approximately 4 years (October 2001 to September 2005).

Based on the results of preloading trials and relevant geotechnical engineering publications, Tetra Tech recommended applying an additional 3m preload layer when groundwater level was at or below 1m AHD, with an additional 1m preload added (total preload of 4m) if groundwater levels rose to between 1 and 2m AHD. The footprint of the preload should extend 20m in all directions beyond the location where foundation improvement is required. The minimum time for preload to be in place is 3 months and there is no upper limit to this time.

Other recommendations are provided to reduce risk of adverse settlement for low rise residential construction. This treatment is also suitable for construction of roads, minor embankments, service corridors and water retention structures subject to appropriate design considerations. Construction of heavily loaded structures such as multistorey buildings would typically have foundations on the underling sandstone / shale bedrock.

The effectiveness of the preloading is illustrated by a sample of monitoring illustrated in Figure 6-2 (following page).

The results presented in Figure 6-2 (following page) show that, for the area under surcharge placed in or before August 2016, the rate of settlement had declined to a low rate by February 2018. The settlement rate would reduce still further when the additional surcharge load is removed prior to site construction. By design, the amount of load removed exceeds the design loading which provides a "safety factor". From the theory and practice of soil mechanics, rate of settlement decreases exponentially with time. For example, if soil settles 15mm in 5 years, the next 15mm of settlement will take 50 years. Thus, preloading for several years before development has a long-term beneficial effect on foundation performance.

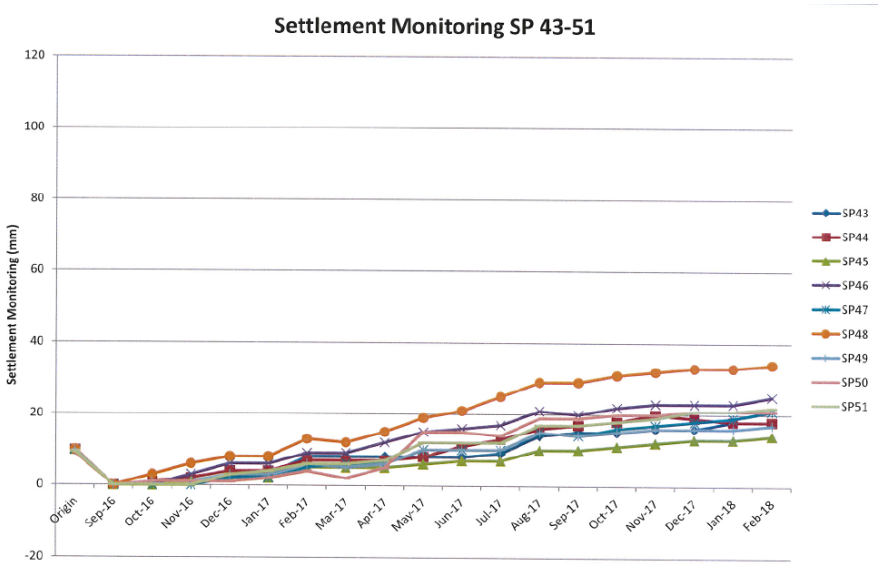


Figure 6-2 – Sample settlement records - Besmaw Kurnell site

Given the current record of preloading treatment for fill material, the future condition of fill material used for rehabilitation of the quarry void in Lot 2 South will be an advantage for all proposed parks, and landscaped and paved areas, as well as for buildings up to 2 storeys such as those in the Bate Bay and Boat Harbour Precincts. The results of preloading will not disadvantage construction of footings and other support systems for buildings having more than 2 storeys and is expected to be an advantage for basement excavation in taller buildings.

7. GEOTECHNICAL DISCUSSION AND RECOMMENDATIONS

7.1 BUILDING FOUNDATIONS

7.1.1 Proposed development on Lot 2 South

The beneficial effects of preloading are not required at the boundaries of Lot 2 South because foreshore dunes were retained and stabilised by vegetation in the south and a wide buffer of sand was not disturbed along other boundaries. A natural sand profile is favourable for construction of low rise structures as settlement under load occurs very quickly in sand and sand foundations are not subject gradual settlement over time.

The depth of dredging and natural angle of repose of saturated sand extends the influence of this boundary buffer an additional 25m into the site. The 20m additional area for preloading can be in the wider buffer area so that foundation improvement by preloading covers the area not affected by the wider buffer area. Tetra Tech notes that this natural soil area coincides with limitations on land use including stormwater management and the foreshore sand dune area at the southern end of the site. The portions of the site where the natural pre-development sand profile will remain are illustrated in Figure 4-1. These areas can readily be developed for recreational areas or roads, or installation of services, where allowable. Tetra Tech identified no part of the site where future development could not be proposed because of geotechnical unsuitability.

Heavily loaded shallow footings such as strip or pad footings for multi-storey (above 6) construction are not likely to be feasible as the underlying fill is not a suitable bearing stratum for such loads. Furthermore, piles founded on the underlying natural sands and clays may not be feasible due to settlement issues under the expected building loads.

7.1.2 Proposed development of Lot 2 North and Lot 8

Subsurface conditions for Lot 2 North and Lot 8 comprise undisturbed sand over sandstone bedrock which is expected to be 16 to 18 m below the current sand surface, similar to conditions in the 100 m wide sand buffer at the northern end of Lot 2 South. A natural sand profile is favourable for construction of low rise structures (up to 2 storeys) as settlement under load occurs very quickly in sand and sand foundations are not subject gradual settlement over time.

The Master Plan proposes several buildings on Lot 2 North and Lot 8 which are 4 or 6 storeys, as well as the ecobridge over Captain Cook Drive, as illustrated in Appendix B. These buildings and ecobridge are associated with higher loadings than low rise buildings and can be carried on sand foundations using accepted design methods, such as larger footings (pad or strip) or by raft foundations above a layer of engineered fill. For future development, individual geotechnical investigation and foundation design would be required to avoid unsatisfactory settlements and more importantly potential differential settlements due to the natural variability in the sand layers.

We note that Lot 9 is not within an area proposed for building or other infrastructure and has not been included in this part of discussion.

7.1.3 Practical foundation design options

To address the presence of fill and/or foundation settlement issues on both lots, options that could be considered for building support include:

- Larger pad and/or strip footings or raft foundations above a layer of engineered fill;
- Pile-to-rock foundations; and
- A combination piled-raft foundation, where piles terminate in natural soil.

Foundations without piled support would likely require excavation of a layer of sand or existing fill (depending on location) and replacement with engineered fill. The feasibility of this type of footing system for a building of up to 15 storeys would depend on the strength and variability of the natural soils.

Pile to rock foundations will likely require piles 20 m to 25 m long socketed into sandstone bedrock. For preliminary design, an allowable bearing capacity of 1,000 kPa may be adopted for footings bearing on the sandstone bedrock. Higher bearing capacities would likely be assessed once boreholes are drilled at proposed building locations.

It has been our experience in the area that a piled raft foundation may potentially be more cost effective compared with a fully piled-to-rock foundation.

For future development, detailed geotechnical investigation for the building location and design loadings would be undertaken using current good practice with professional engineering certification for individual development proposals.

7.2 EXCAVATION AND GROUNDWATER CONDITIONS

As the proposed concept design has a mixture of one and two basement basements in each precinct, as shown on the drawing “1.3 Basement Study” in Appendix B. The design allows for construction of tanked (waterproof) basements, except in areas where the design surface level is at or above 6m AHD. This threshold may require review to allow of potential sea level rise if current assumptions become outdated.

The fill and natural soils should be readily excavated using conventional earthmoving plant such as tracked excavators or wheeled or tracked loaders. Depending on the depth of excavation, groundwater may or may not be encountered during excavation for basements however, two level basements in Town Centre North and Quibray Bay Precincts are likely to require temporary dewatering for construction.

The existing information from Lot 2 South indicated groundwater levels around 1m to 2 m AHD. On Lot 2 North, groundwater has been observed to be from 1 to 2 m below the existing soil surface. The required placement of construction fill to raise the proposed residential area to 5m AHD to mitigate the risk of flooding will minimise interference with groundwater for future development except where a two level basement is planned.

7.3 FURTHER SITE INVESTIGATIONS

We recommend that prior to any detailed building design process that further geotechnical site investigations, including groundwater monitoring, be carried out to support detailed planning and design. The aim of such investigation would be to assess the depth and consistency/strength of the soil profile, depths and quality of the bedrock at relevant locations, the range of groundwater level and response to rainfall and provide data for the design.

Standpipes could be installed into selected boreholes to assess groundwater levels at basement locations and to enable water samples to be collected for water quality/chemistry testing if required.

7.4 SUITABILITY FOR DEVELOPMENT

The distribution of land uses on Lot 2 North, Lot 8 and Lot 2 South proposed in the Master Plan are illustrated in Appendix B.

Based on the processes controlling the nature of fill used for rehabilitation of Lot 2 South and the engineering methods used to treat the placed fill, Tetra Tech considers that, subject to relevant design measures, Lot 2 South (after rehabilitation) and the southern part of Lot 8 will be suitable from a geotechnical perspective for the following uses:

- Construction of one or two storey private and commercial residential buildings,
- Construction of multi-storey residential, commercial or retail buildings using combined raft and piled foundations,
- Landscaping,
- Construction of water features including ponds connected to the groundwater table,
- Provision of service corridors,
- Road construction, and
- Open space recreational areas (playing fields etc).

Similarly, for Lot 2 North, normal earthworks procedures involving placement of fill in layers with controlled compaction of each layer is proposed to raise the ground level to mitigate flood risk and facilitate construction of 2 storey buildings, service corridors and roads, with other foundation systems designed for proposed 4 and 6 storey buildings and the ecobridge over Captain Cook Drive on the western side of the site. Tetra Tech considers that, subject to relevant geotechnical design measures, Lot 2 North will be suitable from a geotechnical perspective for construction of multi-storey residential, commercial or retail buildings, some with basements, and the ecobridge using piled or combined raft and piled foundations.

Given the current record of preloading treatment for fill material, the future condition of fill material used for rehabilitation of the quarry void in Lot 2 South will be an advantage for all proposed parks, and landscaped and paved areas, as well as for buildings up to 2 storeys such as those in the Bate Bay and Boat Harbour Precincts. The results of preloading will not disadvantage construction of footings and other support systems for buildings having more than 2 storeys and is expected to be an advantage for basement excavation in taller buildings.

For the development of specific structures or facilities on the site, appropriate additional site investigation, design assessments, performance requirements (total and differential settlements for new structure and services) and construction monitoring normally associated with this type of development are required, and the potential for structural impacts to neighbouring structures and services should be managed.

8. LIMITATIONS

The preliminary geotechnical assessment and recommendations presented in this report are based on a desk study limited to regional information and our site observations. Subsurface conditions can be complex, vary over relatively short distances and over time. Additional, site specific investigations will be required to support detailed design. Detailed design and construction should not proceed on the basis of this desk study report without further advice from an appropriately qualified and experienced consultant.

The document in Appendix A entitled “Important Information about Your Tetra Tech Report” forms an integral part of this report and presents additional information about the uses and limitations of the report.

APPENDIX A: IMPORTANT INFORMATION ABOUT YOUR TETRA TECH REPORT

IMPORTANT INFORMATION ABOUT YOUR TETRA TECH COFFEY REPORT

As a client of Tetra Tech Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Tetra Tech Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Tetra Tech Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Tetra Tech Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Tetra Tech Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Tetra Tech Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Tetra Tech Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Tetra Tech Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Tetra Tech Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Tetra Tech Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Tetra Tech Coffey to work with other project design professionals who are affected by the report. Have Tetra Tech Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Tetra Tech Coffey for information relating to geoenvironmental issues.

Rely on Tetra Tech Coffey for additional assistance

Tetra Tech Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Tetra Tech Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Tetra Tech Coffey to other parties but are included to identify where Tetra Tech Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Tetra Tech Coffey closely and do not hesitate to ask any questions you may have.

APPENDIX B: SELECTED ELEMENTS OF MASTER PLAN

Kurnell Peninsula Master Plan Urban Design Report
For: Besmaw

The master plan comprises four precincts - each embedded in the unique natural qualities, resulting in distinctly different local character

1 Town Centre

The vibrant home and destination of education and enterprise overlaps people, built form and nature. The Town Centre proposes an appropriate mix and arrangement of land uses, which satisfactorily serve and integrate with the surrounding residential and tourism uses.

The Town Centre will be a place designed for the enjoyment and utility of pedestrians and a place that facilitates access for people between work, home, school and tourist destinations. It will also have;

2 Bate Bay

A unique residential neighbourhood seamlessly woven into the tapestry of parklands, wetlands, and the picturesque coastline of Bate Bay.

This community is a harmonious blend of modern living and the surrounding natural environment, inviting a celebration the rich indigenous and ecological heritage of the area. With the breathtaking 2km beachfront at the doorstep of the community and proposed amenities of Bate Bay, along with vast parklands and heath landscapes, the precinct enjoys the perfect balance of coastal serenity and urban convenience. It will also;

Feature a range of housing typologies to provide a diversity of dwelling types and sizes.

3 Boat Harbour

The Boat Harbour Precinct will be an immersive experience of indigenous knowledge sharing, celebration of culture and a destination.

Boat Harbour is connected to the natural environment. The natural value of the aquatic reserves and marine environment come to the fore in this precinct for residents and visits alike. Boat Harbour will be a place to explore tradition, identity and stories, and a diverse and interesting place to live.

Tourism, residential and recreation uses are key to establishing the local character for this precinct. The diversity of land uses and their connection to the biodiversity and landscape of the site create a character that is unique to Kurnell and Sutherland. Boat Harbour will have;

4 Quibray Bay

A serene residential enclave seamlessly integrated into its natural surroundings, nestled between the tranquil wetlands and the picturesque Quibray Bay.

This thoughtfully designed community offers a harmonious blend of passive open spaces and essential neighbourhood amenities, creating a haven for its residents. With access to the harbour beachfront, native wetlands and unique access off Captain Cook Drive, this community enjoys serene privacy as a contemplative place of passive open space and neighbourhood amenity

The community is served by a community centre and a small pocket of local retail and cafes. The indigenous senior living community enables the opportunity to live on Country and the Cultural Boardwalk at the start of the cultural trail offers a renewed connection to Kurnell's indigenous past and rich culture.

GROUPGSA

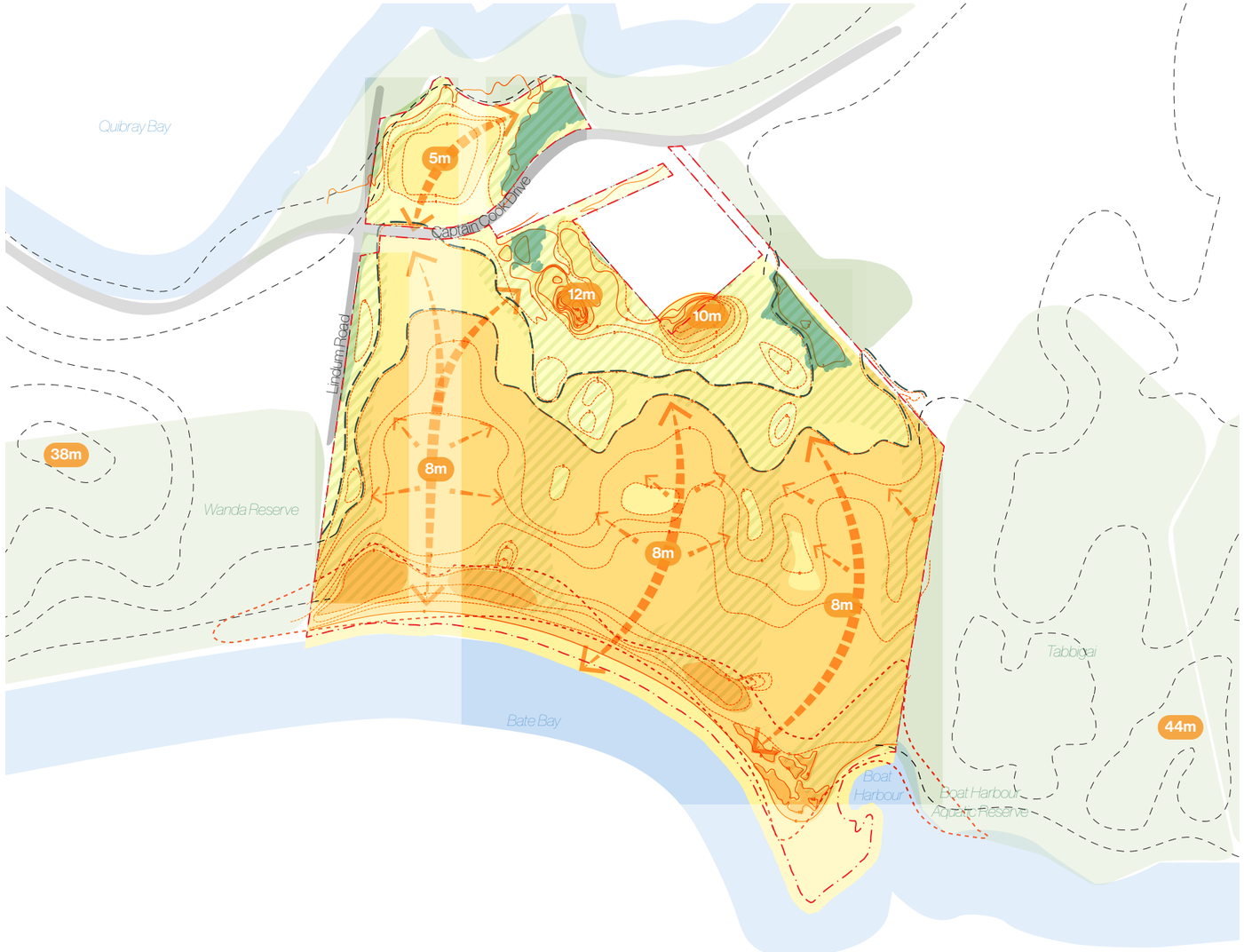
KURNELL

Create a topography that integrates green infrastructure, open space and natural systems

A rehabilitated site topography has been designed to integrate surrounding natural systems. This is reinforced with a series of transitional plateaus, that establish precincts between ecological corridors.

The topography has been designed to facilitate a systems based approach to environmental management, while also supporting a sensitive height strategy that is consistent with the surrounding context. Key strategies to support this intent include;

- Consider transitional plateaus, that can define sub precincts and support a strong place narrative
- Prioritising ecological connections between the plateaus to facilitate movement for fauna in carefully considered biodiversity corridors
- A green web that will seamlessly extent through open spaces, local parks, and waterways. This will enhance biodiversity and foster a sense of continuity within the environment
- The promotion of climate resilient design using the frontal dunes. These will take into account climate change and adapts to potential extreme weather events, such as rising ocean levels or droughts
- Dunes play a crucial role in water management by promoting freshwater retention on-site and preventing runoff into the ocean.
- They also serve as a natural defence against floods, adapting to dynamic coastal processes and anticipated climate change impacts.
- The topographic plateaus shape the four precincts, forming valleys that capture runoff in ecological corridors, effectively mitigating flooding risks in urban areas.



Leverage existing topography for dune experience
Hepburn Springs

Create valley landform for urban wetlands for water collection and reuse
Little Bay Cove | McGregor Coxall

Establish high points to provide panoramic views

OPEN SPACE

Develop a network of open spaces which connect ecology, people and place

The open space network is a dynamic and culturally rich environment that fosters community well-being, ecological sustainability, and engagement with the surrounding indigenous culture and environment.

The open space network is an adaptive environment, evolving with the community and environmental conditions accordingly. It will be supported by;

- A natural environment that actively encourages engagement with Country. Elements such as indigenous artwork, interpretive signs and dedicated spaces explaining the history and significance of the land, and involvement with indigenous communities in the design and maintenance of the open spaces promotes cultural understanding and respect.
- A diverse and interconnected network of open space, seamlessly blending recreational activities with ecological conservation efforts and their adjacent precincts. This network caters to the needs and interests of the proximal community while promoting environmental sustainability.
- A series of local parks, strategically located within each of the four precincts. These parks are within a maximum 400 metre walking distance to all residents and encourage regular community engagement and a healthy lifestyle.
- Three district parks, that not only serve as recreation and sports facilities but are also designed as cultural hubs. This can include spaces for art exhibitions, community events, and cultural festivals, fostering a sense of community and belonging.
- Surrounding green corridors, provide a habitat for local wildlife, native plant species, and offering educational opportunities to engage the community with the environment, promoting an emphasis on ecology.
- A pedestrian centric open space network; with well-maintained walking tracks, the cultural trail, and cycle paths. This will encourage active transportation, reduce the carbon footprint, and enhance the overall quality of life for residents.

Ecological diversity in open space and parklands
Lakeway Redevelopment | Hassell

Mosaic of open space and habitats
First Creek Wetland | T.C.L

District parks provide amenity for residents and visitors
Harold Park | JMD

Pedestrian and shared paths through open space
Johnstons Creek | Phillips Marler

District parks provide amenity for residents and visitors
Lizard Log, Western Sydney Parklands| McGregor Coxall

Local parks provide spaces for daily use
Tote Park, Victoria Park | Hassell

GROUPGSA

3.0 TOWN CENTRE

06

GROUPGSA

1 District Park:

Situated in the Town Centre, the District Park spans across 2.5 hectares. Accessible via the High Street, this park provides a versatile space for local residents and visitors alike, offering exploration, active uses, community hub and gathering spaces.

2 Town Centre:

A 4,400m² supermarket, complemented by retail spaces, restaurants, and cafes sits central to the Town Centre Precinct.

3 School Site:

The 2 hectare school site caters to a capacity of up to 500 learners. Shared sports facilities are intended for use by the school during the day and to the public during evenings and weekends. This collaborative space provides educational and recreational benefits to the broader community.

4 Ecological Corridors:

The Town Centre precinct is flanked by two ecological corridors to the east and west. These corridors are thoughtfully designed to enable the movement of local plant and animal species, ensuring biodiversity and ecological balance in the area.

5 Waterfront Precinct:

The waterfront precinct features a Surf Life Saving Club for safety, alongside restaurants and cafes offering scenic dining. With easy beach access and an innovative Underground Dune Car Park, it combines convenience with preserving the natural beauty of the coastline.

6 Arrival Precinct:

The Arrival Precinct welcomes visitors with learning spaces intricately linked to the Cultural Trail, offering an enriching experience that celebrates the area's indigenous heritage and culture.

7 Waterfront Hotel:

The 115-key waterfront hotel offers a luxury experience, featuring a 5,000m² area housing conference facilities, a selection of restaurants, and extensive grounds with a pool. This hotel provides a sophisticated blend of amenities and scenic waterfront views.

8 Town Centre Hotel:

The 98-key hotel is strategically positioned adjacent to the town center, offering convenience and accessibility to visitors. This establishment boasts 4,500m² of space accommodating conference facilities, restaurants, and retail uses.

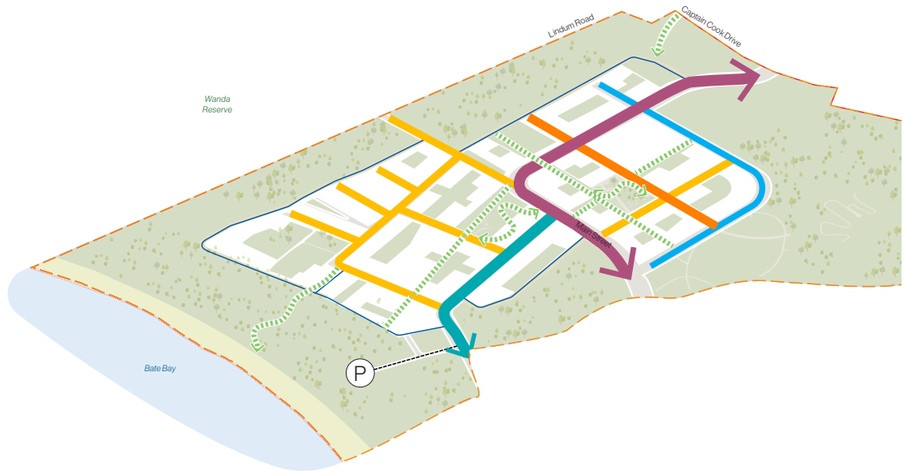
GROUPGSA

3.2 PRECINCT CHARACTER AND DESIGN

The Town Centre has been strategically designed to establish a distinctive character and identity that reflects the Sutherland Shire.

The streets play a significant role in defining the recognisable movement network unique to the Town Centre, contributing to its distinct character. Varied building heights define the Town Centre, forming the urban central core of the Master Plan.

The diversity in housing contributes to the variety in demographics, welcoming people of different ages and backgrounds to live, visit, and stay within the Town Centre precinct.



3.2.1 Connections

The streets in the master plan will feature high quality streetscape design, high amenity bus stops and integrated wayfinding for residents and visitors. The road hierarchy will ensure commuters, residents, and visitors can move around and through the Town Centre safely and efficiently. A number of roads are proposed for the precinct to support the vision and local character for this precinct.

The Main Street boulevard will be a multi lane road that connects all three precincts in Lot 2 South. This will balance the need for carrying a volume of traffic and buses as well as catering for pedestrian connectivity. The Main Street orientation supports the height strategy in a north-south direction as the most dense part of the precinct.

The High Street passes through the retail centre and heart of the Town Centre north, the most urban community. This offers wider footpaths to support the retail activation to destinations such as shops, services and transit stops.

In Town Centre South, the Residential Boulevard provides the major north-south connection. This will be an attractive street that will support multi-modal movement of local residents. The remaining streets are residential in nature. These will have a lower speed and volume of vehicular traffic, to support cycling and pedestrian connectivity.

The Waterfront Dune car park is built into the landscape, allowing unimpeded access and views as visitors arrive over the dune, towards the ocean. The design allows access to the beach for all whilst reinforcing the precinct's flood defences.

The precinct is intricately designed to connect seamlessly with the surrounding areas and Captain Cook Drive. Its layout prioritises fluid integration with neighbouring precincts, fostering easy access and connectivity.

3.2.2 Building Heights

The approach to height for the Town Centre is supported by the vision for the precinct as the most dense and urban neighbourhood in the master plan.

Both north and south precincts have a consistent strategy, to locate the tallest buildings along the topographic ridgeline.

For Town Centre North, the topographic response results in 12 storey buildings located on the main Boulevard to reinforce the urban nature of the precinct. Supported with activation at ground level, this will assist in creating a vibrant precinct with a night time economy. The 12 and 10 storey buildings proposed will be mean that district views can be captured from apartments towards the Sydney CBD and Bate Bay. These taller buildings have been located to avoid bulk and scale when viewed from the District open space and biodiversity corridors.

In Town Centre North, heights transition away from the Boulevard down to 4-6 storeys along the District Park. This ensures that residents will enjoy views to the open space and biodiversity corridors.

In Town Centre South, a greater range of housing diversity is proposed, the maximum building height is 10 storeys, tapering down to 2 storey townhouses adjacent to the biodiversity corridors. A six storey hotel is proposed at the southern most end of the precinct, to ensure that water and CBD views are captured and are uninterrupted.

7.0 BATE BAY

07

GROUPGSA

1 District Park

The 2.2 hectare district park serves as a centralised area for hosting community events, facilitating recreational activities, and managing water resources, catering to the needs of both local residents and visitors. Situated in close proximity to residential dwellings, townhouses, and the main road, it offers a convenient and easily accessible location for all.

2 Local Park

The 0.2 hectare local park is designed with green spaces and walking paths that connect to surrounding trails and amenities. The park features playgrounds designed for children of the community.

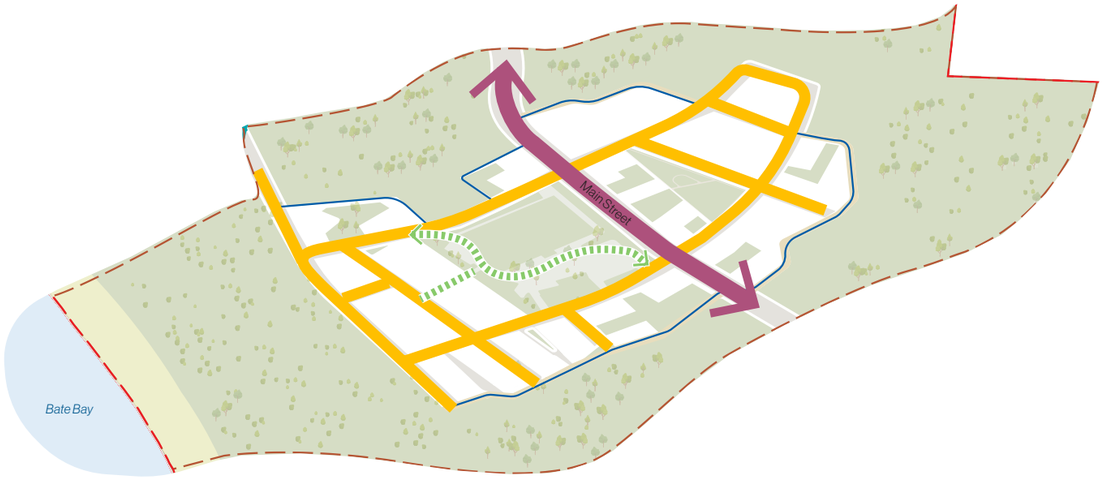
3 Local Retail

A series of north-facing retail spaces grace the perimeter of the district park, creating a bustling hub for convenience and community interaction. Smaller local retail amenity are situated along the edges of Bate Bay North's local park. These cafes provide picturesque views, making them spots for visitors to relax and enjoy the surroundings

4 Ecological Corridors

These corridors serve as vital connections between various natural spaces, promoting biodiversity and fostering a sense of being nestled within nature for residents, visitors and for native flora and fauna to flourish.

7.2 PRECINCT CHARACTER AND DESIGN



LEGEND

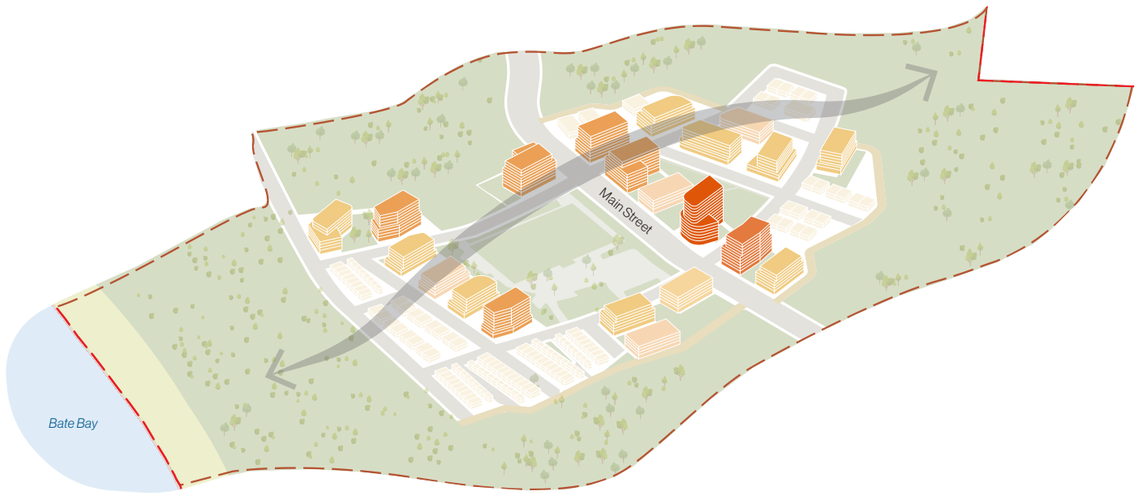
- Main Street
- High Street
- Residential Boulevard
- Collector Street
- Residential Street
- Pedestrian Link
- Perimeter Road
- Access Road
- Underground Public Parking

7.1.2 Connections

A predominantly residential street typology is proposed for Bate Bay to support its intended use and character. Bate Bay north and south comprise of the residential street typology. This will enhance and support the residential neighbourhood character, that has been designed to prioritise walkability and access for residents.

The Main Street bisects this precinct and will support multimodal movement of local residents. The remaining streets are residential in nature. These will have a lower speed and volume of vehicular traffic, to support cycling and pedestrian connectivity.

A number of laneways are proposed in this precinct, to support and reflect the diverse range of housing typologies. These are smaller in scale and will be located near the low and medium density housing, to create a pedestrian friendly street environment, and introduce a finer grain to the master plan.



LEGEND

- One Storey
- Two Storeys
- Three Storeys
- Four Storeys
- Five Storeys
- Six Storeys
- Eight Storeys
- Ten Storeys
- Twelve Storeys

7.1.1 Building Heights

The Bate Bay precinct embraces a balanced approach to urban development. It offers a diverse range of building heights, including 2-storey townhouses, 4-story medium-density apartments, and 6-10 storey apartment buildings.

Notably, building heights gradually decrease towards the northern and southern extents of the precinct, allowing a larger number of residents to access ocean and city views.

A key aspect of the precinct's design is the strategic placement of higher-density housing around the district park, public transport and amenity. This design enhances accessibility to local amenity and fosters a sense of community by clustering more residents near green spaces.

8.0 BOAT HARBOUR

08

GROUPGSA

1 District Park

Situated south of the Boat Harbour Hotel, the District Park spans across 2.5 hectares. Formal gardens offer guests at the hotel an outdoor sanctuary and channels visitors of Boat Harbous southwards towards the beach.

2 Local Park

The 0.15 hectare Local Park is an inviting space that has a community facility, catering to the needs of both local residents and visitors.

3 Beachfront Retail

The retail offer, such as a brewery or beachside restaurant, provides a welcome break from the beach and sun. An ideal spot for visitors to relax, socialize, and enjoy refreshments in a setting with stunning views over Boat Harbour beach.

4 Waterfront Hotel

The Waterfront Hotel offers 190 rooms with scenic views of Tabbigai and the ocean at Boat Harbour and across Bate Bay.

5 Parkview Hotel

The Parkview Hotel comprises 132 rooms and ground level retail spaces that seamlessly connect to the elegant gardens of the District park.

6 Tourism Cabins

Nestled in a natural the natural dune setting, the 52 Tourism Cabins feature sustainable materials, stunning views, and a range of nature-focused activities.

7 Underground Dune Car Park

The second Underground Dune Car Park brings accessibility to Boat Harbour and Bate Bay whilst preserving the natural beauty of the area by not obstructing the coastal landscape. This promotes a more enjoyable and hassle-free experience for outings, picnics, and leisure activities at the beach.

8 City Farm

The indigenous enterprise City Farm merges urban agriculture with indigenous practices, cultivating crops and embracing traditional methods along the Cultural Trail and ecological corridor in Boat Harbour.

9 Community Facility

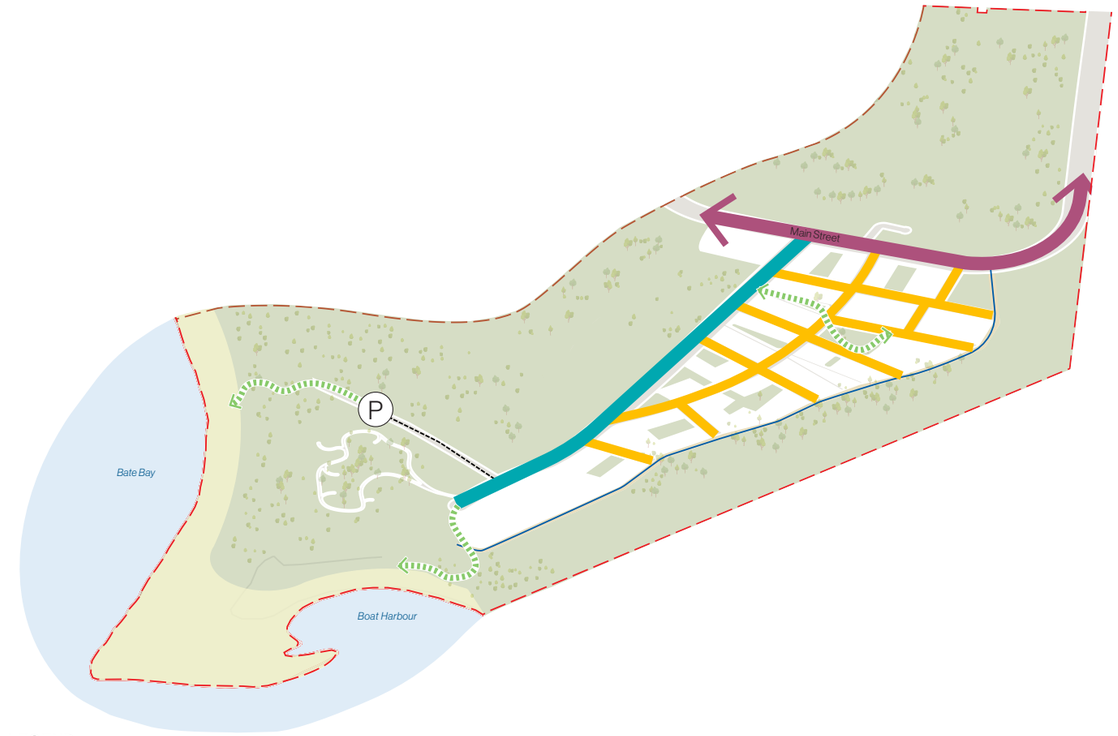
A community facility designed for visitors to the Precinct to discover, explore and celebrate the site's cultural history and ongoing creation of culture.

10 Ecological Corridors:

The Town Center precinct is flanked by two ecological corridors to the east and west. These corridors are thoughtfully designed to enable the movement of local plant and animal species, ensuring biodiversity and ecological balance in the area.

GROUPGSA

8.2 PRECINCT CHARACTER AND DESIGN



LEGEND

- Main Street
- High Street
- Residential Boulevard
- Collector Street
- Residential Street
- Pedestrian Link
- Perimeter Road
- Access Road
- Ⓟ Underground Public Parking

8.2.2 Connections

A predominantly residential street typology is proposed for Boat Harbour to support its intended use and character.

This will enhance and support the residential neighbourhood character and proposed building heights that have been designed to prioritise walkability and access for residents.

The Boulevard runs along the northern interface of this precinct and will support multimodal movement of local residents. The remaining streets are residential in nature. These will have a lower speed and volume of vehicular traffic, to support cycling and pedestrian connectivity.

A north-south residential boulevard that supports vehicular movement to southern end of the precinct. This provides access to the lower scale residential streets and runs alongside the proposed district park.

A number of laneways are proposed in this precinct, to support and reflect the diverse range of housing typologies. These are smaller in scale and will be located near the low and medium density housing, to create a pedestrian friendly street environment, and introduce a finer grain to the master plan.

LEGEND

- One Storey
- Two Storeys
- Three Storeys
- Four Storeys
- Five Storeys
- Six Storeys
- Eight Storeys
- Ten Storeys
- Twelve Storeys

8.2.1 Building Heights

The approach to heights for Boat Harbour has been established to mitigate visual impact to the adjacent national parks and views from the open space.

As such, a maximum building height of 8 storeys is proposed, at the northern end of the precinct where overshadowing and amenity to other uses is not negatively impacted. There are two six storey hotels in this precinct, that are oriented and strategically located to capture water and parkland views.

To remain consistent with the proposed neighbourhood character, taller buildings are located along the Boulevard, while lower density (6 storey) residential flat buildings are located closer to the district park and waterfront.

In the centre of the precinct are two storey townhouses. These create a lower, neighbourhood scale and increase housing diversity. The two storey heights also create a varied architectural skyline, when viewed from the District Park and other open spaces.

9.0 QUIBRAY BAY

09

GROUPGSA

1 Cultural Trail

The Cultural Trail begins its journey in Quibray Bay, on the tranquil waterfront. A community facility is complemented by a north-facing retail space ideally suited for a charming cafe marking the start of the cultural trail, inviting visitors to embark on an enriching exploration of culture and indigenous heritage.

2 Local Park

The 0.15 hectare Local Park is an inviting space that has a community facility, catering to the needs of both local residents and visitors. Positioned in close proximity to the Cultural Trail boardwalk, this park serves as a connecting point, offering a transition between the park and the Cultural Trail.

3 Wetland:

Boardwalks through the extended wetland area will provide visitors and residents with the opportunity to observe native flora and experience the ecosystem firsthand. The journey along these boardwalks will also offer insights into the area's Indigenous history, creating an educational experience for all.

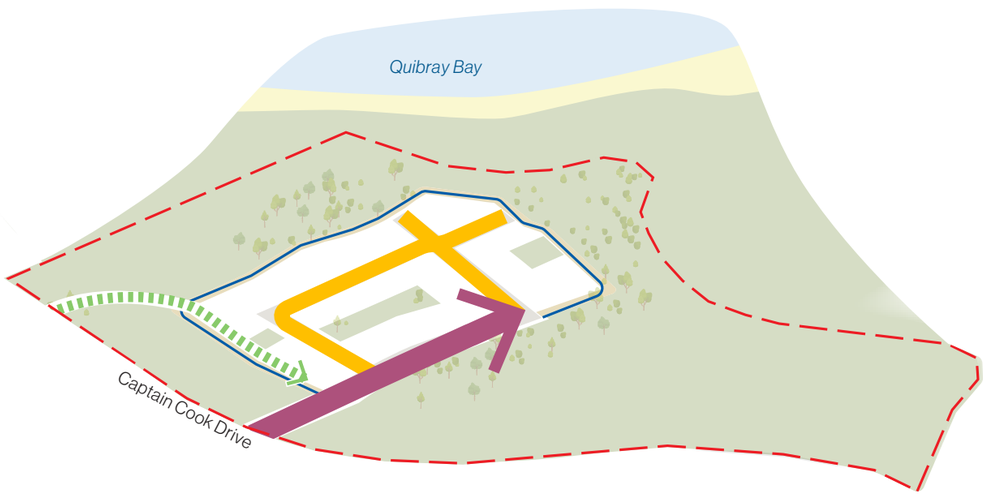
4 Green Land Bridge

The green land bridge serves as a vital pedestrian and cycle link connecting Quibray Bay through the cultural trail to the three southern precincts. This bridge not only physically connects these areas but also symbolises an ecological pathway, fostering safe coexistence of nature and human activity.

5 Indigenous Seniors Living

The Indigenous Seniors Living community is specifically designed for elders to reside on their traditional Country or ancestral lands. These communities are tailored to meet the specific cultural, social, and healthcare needs of the indigenous elders. It's a place to live in accordance with traditional customs, fostering a deep connection to cultural heritage and to the land.

9.2 PRECINCT CHARACTER AND DESIGN



LEGEND

- Main Street
- High Street
- Residential Boulevard
- Collector Street
- Residential Street
- Pedestrian Link
- Perimeter Road
- Access Road
- Underground Public Parking

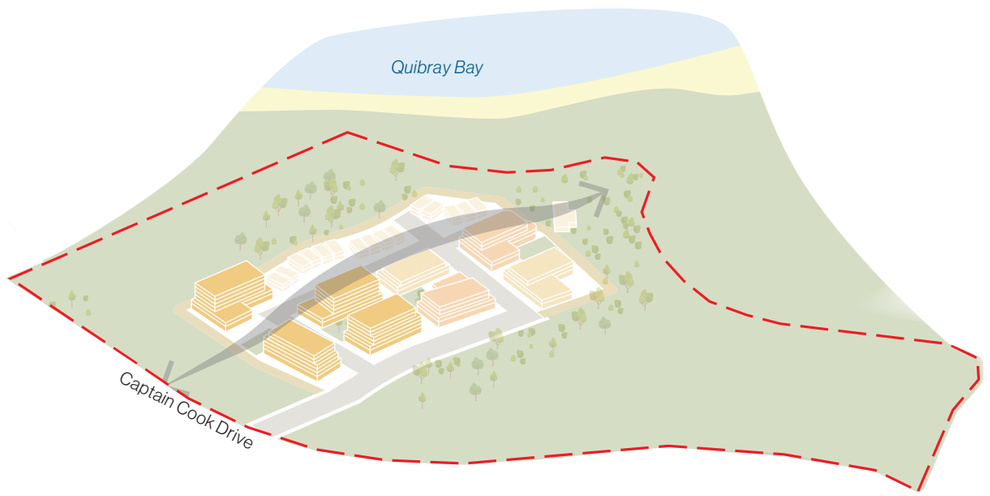
9.2.2 Connections

The Quibray Bay precinct features a self-contained street network, with a local loop-road extending off of a primary north-south road.

This simple network will clearly direct vehicular traffic through and around the site, with a single legible gateway marking the site's single entry and exit point.

The land-bridge across Captain Cook Drive accesses the precinct to its south-west distinct from the proposed vehicular entry point, separating vehicular, pedestrian, and faunal traffic.

Due to the precinct's size, it lacks a distinct pedestrian network or through-site links, with the site's central lot occupied by residential flats.



LEGEND

- One Storey
- Two Storeys
- Three Storeys
- Four Storeys
- Five Storeys
- Six Storeys
- Eight Storeys
- Ten Storeys
- Twelve Storeys

9.2.1 Building Heights

As the smallest of the four proposed precincts, building heights within the Quibray Bay precinct reflect its underlying vision as a tight-knit coastal neighbourhood, with a residential density appropriate for its location.

Proposed built form generally reduces in height towards the precinct's northern interface with Quibray Bay and its coastal wetlands, culminating with the single storey specialised Indigenous seniors community. This will ensure an appropriate scale on the Quibray Bay coast which will not overwhelm the prominence of the existing wetlands.

Building height of up to six storeys is concentrated along Captain Cook Drive and the precinct's primary north-south entry road, creating a prominent gateway set-back from the main road. Additionally this will minimise overshadowing within the Quibray Bay precinct, ensuring solar access to north-facing facades.

Views towards Quibray Bay and further towards Sydney CBD are a key draw of the precinct, with all mid-rise residences of six to four storeys provided with clear northerly views at their upper levels by stepping built form downwards at two to three storeys along the north.