Memorandum

20 November 2019

To	Bala Subramanian, Senior Project Manager, Sydney Water		
Copy to			
From	Gary Leonard	Tel	+61 2 9239 7100
Subject	Arboricultural Impact Assessment relating to the Vaucluse Diamond Bay Wastewater Improvements Project	Job no.	21-28225-15

Dear Bala,

Arboricultural Impact Assessment relating to the Vaucluse Diamond Bay Wastewater Improvements Project- Parsley Bay Reserve

1 Introduction

A proposal to construct a pump station at Parsley Bay Reserve may affect three mature trees growing near the public toilets and car park. An additional two early-mature specimens located near the Kiosk may also be affected. This Arboricultural Assessment has been requested by Sydney Water Corporation (SWC), as a component of ongoing investigations relating to the proposed Vaucluse Diamond Bay (VDB) wastewater improvements project. The Arboricultural Assessment has been carried out on the assumption that the intention is to retain the three trees which are located near areas of proposed excavation and construction and to minimise any harmful impacts, including impacts on other trees and vegetation within close proximity.

1.1 Purpose and scope of the report

GHD Pty Ltd (GHD) has been engaged by SWC to provide advice on potential impacts to three existing trees growing in proximity to proposed areas of excavation and construction and to recommend appropriate protective measures. Each tree is described in this report according to the requirements of Woollahra Municipal Council (2011).

This study involves an assessment of the health of each tree, and the capacity of these trees to continue to grow in good vigour and form, after likely disturbances associated with the proposed VDB wastewater improvements project.

During the site visit, an additional two trees, growing near the Kiosk were also assessed because of their proximity to a proposed vehicular access from the bay to the excavation site.

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1.2 Scope and limitations

This report has been prepared by GHD for Sydney Water Corporation and may only be used and relied on by Sydney Water Corporation for the purpose agreed between GHD and Sydney Water Corporation as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Sydney Water Corporation arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.3 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

1.3 Assumptions

The services undertaken by GHD in connection with preparing this arboricultural assessment:

- Were limited to those specifically detailed in section 1 of this report; and
- Assume that the extent of the proposed excavation and construction works will be consistent with the details provided during the initial site meeting on 25 September 2019.

2 Methodology

2.1 Desktop review

The following documents were reviewed prior to the site assessment:

- Woollahra Municipal Council (2011) Tree Management Policy
- Woollahra Municipal Council (2014) Street Tree Master Plan
- Woollahra Municipal Council (2015) Biodiversity Conservation Strategy, 2015 to 2025
- Topographical survey, Parsley Bay Reserve. Prepared by Cardno
- Proposed works sketches, prepared by GHD.

2.2 Arboricultural Survey

Arboricultural assessments were carried out on 25 September 2019 by Gary Leonard, GHD Arborist and Senior Botanist (International Society of Arboriculture membership no. 212238 and Arboriculture

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Australia membership no. 2173). The survey was carried out in association with Sadia Abdullah, Civil Engineer-Water Infrastructure, GHD who provided details relating to the proposed excavation and construction.

2.2.1 Visual Tree Assessment

The three trees in the subject site and the two trees located near the Kiosk which may also be affected, were assessed by conducting a ground-based Visual Tree Assessment (VTA) (see Matheney and Clark 1994a and 1994b).

Attributes for each tree recorded included:

- Tree No
- Botanical name of tree species
- Common name of tree species
- Height of tree in metres (m)
- Spread (radius m.)
- Diameter at Breast Height (DBH) (m)
- Age class
- Health
- SULE and SRIV
- Theoretical TPZ
- Comments.

The height and crown spread of trees were estimated. The diameter of each tree at breast height (dbh) was measured using a Forestry DBH tape. Root mapping was carried out, in order to estimate potential root loss, which may result from proposed excavation works. Tagging of the trees was not necessary, because of the ease of on-site location, with reference to paths, buildings and other features. The information provided in this report reflects the condition of the trees at the time of inspection and only relates to the trees surveyed.

2.2.2 Structure and Health

For each tree, the Safe Useful Life Expectancy (SULE) was determined based on the health and structure of the subject tree (after Barrell, 2001). The SULE code is provided in Appendix A. The Sustainable Retention Index Value (SRIV) and Significance Value (STARS), according to IACA (2010a and b) were also determined. The health and structural integrity of each tree were evaluated according to the criteria outlined in (Table 1).

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Table 1 List of items used to determine tree structure and health.

Structural Considerations *	
Presence/absence of cankers (abnormal growth caused by fungi or bacteria)	Evidence of 'end weight' (accumulation of mass at the end of a branch)
Presence/absence of cavities (open wound with evidence of decay)	Presence/absence of epicormic shoots (shoots arising from latent or adventitious buds)
Presence/absence of co-dominant stems (Stems or branches of equal diameter, often weekly attached)	Presence/absence of previous branch or trunk failure
Presence/absence of conks (fruiting body of decay fungi e.g. Bracket Fungus)	Evidence of girdling roots (roots that encircle the base [above ground] of the stem)
Presence/absence of decay (degradation of wood by fungi / bacteria)	Leaning trunk (bias)
Evidence of decline (loss of vigour)	Low canopy (branches that are close to ground may require heavy pruning for construction clearance)
Evidence of dieback (death of twigs and branches)	Presence/absence of wounds (injuries on the surface of a stem or branch)
Health Considerations	
Presence/absence of pest and diseases	Proportion of necrotic material in platform
Amount of extension growth	Absence/presence of epicormic growth
Density of canopy	Foliage size and colour

The estimate of a tree's age was based on the definitions outlined by Draper and Richards (2009). Trees were classed as follows:

- Young (Early Mature): age <20% of their life expectancy *in situ*
- Mature: aged between 20 to 80% of their life expectancy *in situ*
- Over-mature: aged >80% of their life expectancy *in situ*.

2.2.3 Tree Protection Zones

The Tree Protection Zone (TPZ) has been calculated for each tree, according to *Australian Standard 4970 'Protection of Trees on Development Sites'* (SA, 2009) (see Appendix B). It is, however, stressed that this calculated TPZ is theoretical and does not necessarily apply to the subject trees because of their location on sandstone, and partly enclosed within constructed kerbs, drains, walls and roads. The calculation of TPZ by measuring dbh of Fig species is further complicated by the development of an aerial root column, rather than a "trunk". The aerial root column may be hollow, moreover the development of buttresses will greatly inflate the dbh (see Adam 1992). The TPZ is calculated according to the following formula:

TPZ radius = DBH x 12 where: DBH = Diameter at Breast height (in metres).

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In the case of Tree 1, which has co-dominant leaders, the following formula was applied, in order to calculate DBH:

DBH=(dbh1^2+dbh2^2+...+dbhn^2)^0.5

The TPZ calculation according to SA (2009) is stated for each tree in Appendix B

3 Results

3.1 Location

The subject site is located within a section of Parsley Reserve (see Photos 1, 2 and 3) Vaucluse, in Sydney's eastern suburbs. Parsley Reserve was managed as a Reserve by Vaucluse Council from 1907 and by Woollahra Council from 1948, after the two Councils merged. "…. the Reserve remains a popular place for more intimate picnic parties, and, since the 1970s, for weddings. It has also formed the backdrop for a number of films, commercials and television programs in recent decades. Woollahra Council has continued to maintain the Reserve and beachfront and in recent years has pioneered a bush regeneration program in the gully area, allowing the native species to prevail following the eradication of exotics" (Woollahra Library History Centre 2005).

The topsoils appear to have undergone past and recent disturbances, especially levelling for the lawn and parking areas. The original soils in this area would have been derived from soils of the Hawkesbury Soil Landscape Group. Soils of the Hawkesbury Group are derived from Hawkesbury Sandstone and consist of "… medium to coarse-grained quartz sandstone with minor shale and laminite lenses (see Chapman and Murphy 1989). Tree 1 and Tree 2 occur on soils derived from the Hawkesbury Group, although it is possible that Tree 3 is growing within a previously levelled area.

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Photo 1 Levelled area developed as carpark.

Photo 2 Levelled area developed for recreation.

Photo 3 View from playground. Entrance to Reserve right middle-ground; Tree 2 centre. Trees and vegetation on the site.

Original vegetation on the site would have consisted of Tall Woodland and Open-forest on Sandstone, with closed forest along sheltered creek lines (see Benson and Howell 1990; Woollahra Municipal

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Council 2015). The existing vegetation within the Reserve is mapped as Sydney Foreshore Shale Forest on the level areas, with Coastal Sandstone Foreshore Forest on the slopes and sandstone terraces (see NSW NPWS 2012, Woollahra Municipal Council 2015). Common tree species would have included Smooth-barked Apple (*Angophora costata*), Sydney Peppermint (*Eucalyptus piperita*), Old Man Banksia (*Banksia serrata*) and Black Oak (*Allocasuarina littoralis*). Mid-storey species would have included Black Wattle (*Callicoma serratifolia*), Water Gum (*Tristaniopsis laurina*) and Ironwood (*Backhousia myrtifolia*). These species are still present in vegetation patches, as either natural occurrences or the result of planting (see Woollahra Municipal Council 2015).

Although the three subject trees are indigenous to Woollahra LGA, it is possible that they have been planted (see Woollahra Municipal Council 2015). The three trees appear to be more than 100 years old.

The two trees growing near the kiosk are also indigenous to Woollahra LGA and have been planted, probably less than 15 years ago.

Although this survey did not include a botanical assessment, the occurrence of two threatened plant species was noted, because they occurred within an area adjacent to Tree 1, which is identified as an alternative site for the pump station. A sawn stump of Magenta Lilly Pilly (Syzygium paniculatum) with epicormic regrowth was recorded at the base of the retaining wall, to the northeast of Tree 1. A number of seedlings were recorded which were tentatively identified as Syzygium paniculatum, although the occurrence of Syzygium smithii and Syzygium australe seedlings in the same vegetation patch created uncertainty. A mature specimen of Sunshine Wattle (Acacia terminalis subsp. terminalis) was recorded near the Magenta Lilly Pilly stump. A more detailed ecological assessment of the site will be carried out in the future as part of the approvals process for the project.

The vegetation in and adjacent to the subject site is well maintained and most trees are in good form and health (see photos 4, 5 and 6).

Photo 4 Thicket of (probably planted) Bangalow Palms, west of the toilet block.

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Photo 5 Planted and self-recruited vegetation to the west of the toilet block. Two threatened plant species were recorded in this patch.

Photo 6 Creek line vegetation, north of the toilet block.

The locations of surveyed trees are indicated on Figure 1. Details of surveyed trees are presented in Section 4 below and in Appendix B.

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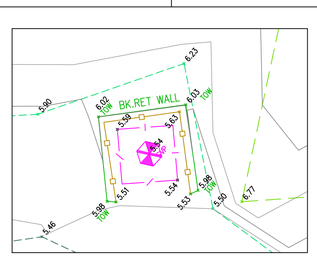

DIAGRAM 2
1:50

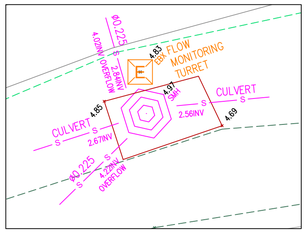

DIAGRAM 3
1:50

Protected species (Syzygium paniculatum) One plant near carpark (east of the toilet block) Coordinates: X = 340760.540 Y = 6252836.201

New storage tank underneath the car park

Low hanging branches over the road to be cut off for construction plant access/safety (area shaded yellow)

New sewer diversion (approx 2m dia pipe, 3m deep)

Access routes for construction plant to the site shown with red arrows (from shore over the tree route zone), or from Horler Avenue

Tree 2

Tree 1

Tree 3

Section of road to be widened is shaded in red (approximate only)

Protected species (Syzygium paniculatum) Multiple found near MH with flow turret (west of the toilet block) Coordinates: X = 340723.056 Y = 6252854.907

Pumping station site within red box, which involves excavation of up to 8m depth. Fig tree branches on top of site to be cut off (shaded in yellow)

PARSLEY BAY RESERVE

GRASS

7324

PLAYGROUND

DP 1160044

TABLE & BENCHES ON CONC. SLAB

FOOTPATH

BITUMEN CARPARK

BRICK BLDG.

TOILET BLOCK

2 STOREY RENDERED RESIDENCE TILE ROOF

SEE DIAGRAM SHT.5

DIAL BEFORE YOU DIG www.1100.com.au

SCALE 1: 200 @ A1

IMPORTANT NOTE:
This plan is prepared for GHD from a combination of field survey and existing records for the purpose of designing new constructions on the land and should not be used for any other purpose.
The title boundaries shown hereon were not marked by the author at the time of survey and have been determined by DCDB only and not by field measurement.

A services search of the area surveyed above has not been undertaken. Visible services shown hereon have been located where possible by field survey. Prior to any demolition, excavation or construction on the site, the relevant authority should be contacted for possible location of further underground services and detailed locations of all services.
This note is an integral part of this plan.

REVISION	DATE	DESCRIPTION	CCAD REF	APPROVED
01	18/07/2019	ORIGINAL ISSUE (PRELIMINARY)	118941AC	M.C.

SCALE:
HORZ. 1: 200 VERT.
A1
CONTOUR INTERVAL:
MAJOR 1.0 MINOR 0.5
HORIZONTAL ORIGIN
COORD. SYSTEM: MGA
MARK ADOPTED: SSM 76753
COORDINATES: E 340 547.036 N 6 252 923.294
VERTICAL DATUM
DATUM: AHD
BM ADOPTED: SSM 76753
RL: 18.413

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SURVEYED	DRAWN	CHECKED	PASSED
J.E.	A.G.	J.E.	M.C.

PARSLE

HOWING DETAIL, LEVELS & CONTOURS

CLIENT: GHD

SHEET 3 OF 5

DRAWING NUMBER	REV
11894101001	01

4 Tree Descriptions

4.1 Tree 1

Tree 1 is a Small-leaved Fig (*Ficus obliqua* G. Forst var. *obliqua*). Small-leaved Fig is described by Floyd (1989) as "….a large tree attaining its best development in luxuriant rainforest…..An excellent shade tree in parks". Tree 1 has one large and a smaller aerial root column and a low, broadly spreading platform, with two large laterals extending over the toilet block (Photo 7). Surface roots extend outwards from the aerial root column towards the toilet block, but especially away from the toilet block to the palm thicket (Photo 8).

Photo 7 View of aerial root column and lower platform. Note laterals extending over building.

Photo 8 Tree 1. Note growth of surface roots beneath path and into palm thicket.

Although the theoretical TPZ of the tree would be 15 m (see Standards Australia 2009), it is apparent that there is a greater concentration of roots to the south-west of the aerial root column, where surface roots were recorded within a palm thicket and at the base of a sandstone platform. Roots survive in areas with adequate nutrients, moisture and air, therefore it is reasonable for a greater concentration of roots in the garden beds rather than towards and underneath the building. Some

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surface roots were recorded growing towards the building, but it is apparent that the footings of the building have acted as a root barrier, either discouraging further root growth or directing root growth away from the building (see Hallé, Oldemann and Tomlinson 1978, Hitchmough 1994, Harris, Clark and Matheny 1999, Perry 1982).

The two laterals which extend from the platform over the toilet block will require removal, to provide machinery access during excavation and construction (Photo 9).

Photo 9 **Two laterals, extending in a north-easterly direction over the toilet block.**

Tree 1 is in good condition, with a dense canopy. Necrotic branches and decay in old wounds are uncommon. The tree has a SULE rating of 1A, a SRIV rating of MGVG-10 and a STARS rating of High Priority for Retention. Tree 1 is not included in Council's list of Heritage Trees (see Woollahra Municipal Council 2014; 2015), but has a high STARS rating because, of the criteria for inclusion as having high significance in the landscape, the following criteria apply:

- The tree is in good condition and good vigour
- The tree has a typical form for the species
- The tree is a (probably) planted locally indigenous species
- The tree is visually prominent and visible from a considerable distance when viewed from most directions within the landscape due to its size and scale and makes a positive contribution to the visual amenity.
- The tree supports social and cultural sentiments or spiritual associations, reflected by the broader population or community group (see IACA 2010b).

4.2 Tree 2

Tree 2 is a Small-leaved Fig (*Ficus obliqua* G. Forst var. *obliqua*). It is possible that Tree 2 was planted during the same period as Tree 1. Tree 2 does not have the same dimensions as Tree 1, although this may be explained by factors, including genetic variation, location, soil type and depth, moisture levels and protection.

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Tree 2 also has a SULE rating of 1A, a SRIV rating of MGVG-10 and a STARS rating of High Priority for Retention (see 4.1 for a list of criteria for high significance in the landscape). Tree 2 is not included in Council's list of Heritage Trees (see Woollahra Municipal Council 2014; 2015).

Tree 2 has good vigour and form, and no evidence of significant decay in wounds derived from previous lateral removal. The theoretical TPZ of Tree 2 is 15 m, although it is apparent that excavation for drains, underground surfaces, kerbs and sealed areas have removed some portions of the tree's root zone, and possibly concentrated most root growth towards less disturbed areas. Surface roots extend across the mulched bed and towards the creek line, as well as beneath the asphalt seal (Photo 11 and Photo 12). The canopy is low and spreading, with large laterals extending across the entrance to the carpark.

Photo 10 Tree 2, showing location within mulched bed. Note laterals which extend over entrance to carpark.

Photo 11 Red-coloured roots in creek line adjacent and north of Tree 2 (centre, middle-ground) may have originated from Tree 2.

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Photo 12 Roots extending from Tree 2 beneath asphalt and into carpark.

4.3 Tree 3

Tree 3 is a Plum Pine (*Podocarpus elatus* R. Br. ex Endl.). Plum Pine is a conifer with a fleshy fruit, "…..eaten by green catbird, pied currawong, satin bowerbird and wompoo fruit-dove", and occurs …. in littoral, riverine and subtropical rainforest" (Floyd 1989). Distribution of this species extends along Eastern Australia from Batemans Bay to Cairns. It is likely that Tree 3 has been planted, although it is indigenous to the area and is growing in suitable habitat.

Tree 3 is mature and is in good condition and form (Photo 13). Some laterals have been previously removed back to the leader, although no evidence of significant decay was recorded in any of the wounds. The tree's platform is partly suppressed to the north-east, with the result that there are long, low laterals to the south, extending across Horler Avenue at the entrance to the Reserve (Photo 14).

Photo 13 Tree 3. Edge of Horler Avenue can be seen in foreground.

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Photo 14 Canopy of tree 3, extending over Horler Avenue.

Tree 3 has a SULE rating of 1A, a SRIV rating of MGVG-10 and a STARS rating of High Priority for Retention. Tree 3 is not included in Council's list of Heritage Trees (see Woollahra Municipal Council 2014; 2015), but has a high STARS rating because it complies with more than three of the criteria for inclusion as having high significance in the landscape (see 4.1 for list of criteria for high significance in the landscape).

The theoretical TPZ of tree 3 is 10 m. It is likely that roots growing beneath the road have been cut, possibly during installation of the kerb and is likely that there is a greater concentration of root growth to the north-east, especially along the base of the sandstone shelf.

4.4 Additional trees that may be affected by site access

Two early-mature specimens which are growing near the Kiosk have also been assessed because of their proximity of the area proposed for vehicular access from the bay to the excavation area. Both specimens are Smooth-barked Apple (*Angophora costata* [Gaertn.] Britten). Both specimens are early-mature and in moderate form and condition. Their form is described as moderate, because of their distorted leader growth and narrow platform. Condition is described as moderate because of their sparse canopies. Apparent stress factors include isolation, proximity to buildings which may create vortex effects (see James 2010) and a dense groundcover of exotic grasses over the root zone (see Hitchmough 1994).

Although probably planted at the same time, the specimen nearer the Kiosk (Tree 5) is larger and in better condition, compared within the specimen nearer the entrance to the car park (Tree 4). Tree 4 is 10 m tall, with a canopy radius of 3 m. DBH is 0.22 m and the TPZ is 3 m. SULE of Tree 4 is 2A and SRIV is MGVF-9. Tree 5 is 14 m tall, with a canopy radius of 4 m. DBH is 0.28 and the TPZ is 4 m. SULE of Tree 5 is 2A and SRIV is MGVF-9.

It is possible that the vehicular access from the bay to the excavation site will encroach on the TPZs of these trees (Photo 15).

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Photo 15 The access track for vehicles will pass near the two early-mature trees in right of picture (Trees 4 and 5). The TPZ surfaces of these trees should be adequately protected during the period of vehicular access.

5 Potential impacts of proposed works, in the context of the subject trees

5.1 Tree 1

Proposed works include the removal and excavation of the toilet block building for construction of a new wastewater pumping station.

A new pumping station will be located over the site of the toilet block building and extend further east towards the reserve. The following works will be carried out:

- Excavation for installation of a wet well; 5 m dia. and 7 m depth
- Excavation for a valve chamber; 4 m long, 3 m wide and 3 m deep
- Excavation for a new maintenance hole; 3 m dia. and 7 m deep
- Excavation for a new diversion structure; 5 m length, 3 m wide and 7 m deep
- Excavation for associated pipework and conduits (up to 3 m deep)
- Construction of a ramp for machinery access
- Possible relocation of sewer; 2 m diameter. 3 m deep.

Potential impacts to Tree 1 are likely to include:

- Lower laterals, especially those extending over the toilet block roof will need to be removed
- Some roots extending beneath the toilet block floor may require removal
- Some roots may require removal if growing within proposed relocated sewer
- Surface roots and the aerial root column may be damaged during excavation for associated pipework

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- Surface roots and the aerial root column many be damaged by machinery access during works.

Removal of laterals is further complicated by branch grafting which has taken place, including within the laterals extending over the toilet block roof (Photo 16).

Photo 16 Grafted laterals; Tree 1.

Removal of laterals and therefore of foliage will reduce the tree's photosynthetic capability. Removal of or damage to fine roots will reduce the tree's recovery capability, and removal of supporting roots may inhibit stability as well as removing stored energy (see Hallé *et al.* 1978, Hamilton 1989, Perry 1982).

5.2 Tree 2

At least one large lateral, extending over the car-park entrance may need removal (Photo 18). The road surface may be compacted as a result of heavy machinery operation over the tree's TPZ.

Excavation to the south and east of Tree 2 will occur within the tree's theoretical TPZ, potentially removing fine roots and supporting roots.

The stress factors outlined in 5.1 would also apply to any reduction of foliage and roots of Tree 2.

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Photo 17 Large lateral of Tree 2 over car-park entrance (left of picture).

5.3 Tree 3

It is likely that the laterals growing over Horler Avenue will need to be removed, to facilitate vehicular access, thereby reducing the tree's photosynthetic capability.

It is likely that the actual root zone of Tree 3 is mostly concentrated along the upper slopes, to the north-east of the tree's leader, in which case proposed excavation along the entrance to the car-park would not result in encroachment into Tree 3's TPZ.

5.4 Trees affected by access track

It is possible that a proposed access road for heavy vehicles will encroach onto the northern portion of the TPZs of Trees 4 and 5. Vehicular movement over the TPZs would cause compaction and if sustained over a long period would result in necrosis to fine roots and supporting roots, mainly as a result of reduced available air in the rhizosphere. The tendency for compaction could be reduced if a protective cover is laid across the TPZ.

A proposed relocated sewer may, however cause complications, as it would likely encroach into the TPZs of Trees 4 and 5. Excavation into the TPZs of Trees 4 and 5 would result in loss of fine roots and possibly supporting roots, causing stress factors which are outlined in 5.1.

6 Prognosis and Recommendations

Trees 1, 2 and 3 are currently in good condition and form, moreover they have a high Significance Value, in terms of the location and appearance. The proposed VDB wastewater improvements project will require some loss of canopy and root zone of all trees, but especially to Tree 1, which will require the removal of two large laterals, comprising less than 5% of the total canopy and possibly the loss of a small proportion (probably less than 2%) of roots. There is also the potential for damage to surface roots and the tree's aerial root column, unless appropriate protective measures are followed. Tree 2 will also require removal of a large lateral and, probably reduction in the southern portion of the tree's TPZ.

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Trees 4 and 5 may be marginally affected by road widening over their TPZs as long as the recommended protective measures are carried out, but if the proposed relocated sewer requires excavation within their TPZs, there is a possibility of reduced vigour and also, possibly reduced stability.

The following protective measures are recommended:

- Appointment of a Project Arborist. The Project Arborist should co-operate with the site manager to determine the installation of adequate tree protection fencing. It is, however recognised that the siting of protection fencing according to Standards Australia (2009) will conflict to some extent with the need for vehicular and public access, therefore the Project Arborist will need to determine appropriate compromises, in order to ensure as much tree protection as is possible.
- Root zones located within or adjacent to works area or vehicular access should be protected by the application of either organic mulch, coarse gravel or geocells. The root protection should be installed prior to commencement of works and should not be removed until completion of all works. This measure applies to Trees 1, 2, 4 and 5 (Photo 16).

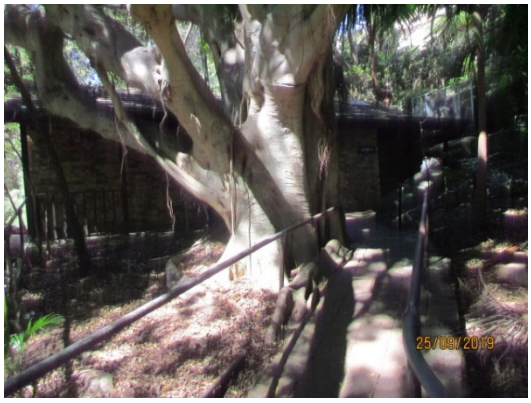

Photo 18 Tree 1, surface roots over this area will require protection from damage and compaction by vehicles.

- Protective fencing should comply with Australian Standards 2009 where possible. An example of appropriate fencing is indicated in Appendix D. The fencing should be installed prior to commencement of clearing and should be retained in place until the completion of construction
  - The following actions should not be permitted within the TPZs:
  - Storage of materials, plants or equipment
  - Installation of site sheds or portable toilets
  - Excavations, trenching, ripping or cultivation of soils
  - Modification of existing soil level or addition of fill materials
  - Disposal of waste materials and chemicals (both solid or liquid)
  - Mechanical removal of vegetation

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  - Pedestrian or vehicular movement.
- Any root pruning required within the TPZs should be approved by the Project Arborist and any digging and pruning of roots (only roots < 5 cm may be pruned) within the TPZ should be conducted by hand for a clean cut. In the case of Trees 4 and 5, if the proposed sewer re-location requires the removal of more than 10% of their TPZs, the Project Arborist should determine whether the trees will survive the proposed disturbance and to either recommend ameliorative actions or to propose replacement planting
- Removal of large laterals should be supervised by the Project Arborist. Ideally, laterals should be removed back to the aerial root column. All pruning should be carried out with reference to Safe Work Australia (2016) and to Standards Australia (2007)
- Irrigation systems may need to be installed if the current extended period of drought conditions continue. As a guide, the watering should occur at least once per week and allow deep soil penetration. The specific watering requirements will also depend on the climatic conditions.
- Once the construction works are completed, retained trees should be re-inspected by the Project Arborist who should carry out a more in-depth assessment that would prescribe remedial work where necessary to reduce the risk to pedestrians or parked vehicles.
- The retained trees should be monitored after completion of the proposed development to assess their health, vigour and to identify potential hazards. This is of particular importance given the proximity of the trees to areas of public access.

It is important to note that some defects, ill-health or decay in a tree are not always identifiable using VTA. In addition, there are occasions where supposed healthy and defect-free trees break or are damaged by wind-throw, especially those trees growing along a newly created edge. This is described as a ‘normal failure rate’ and is a function of the energy-saving, cost-effective and lightweight structure of a tree. Therefore, every tree represents some potential danger of failure (see Mattheck and Breloer, 2003). The trees should be monitored by the Project Arborist at six months and one year after completion of the works.

Regards

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Appendix A: Safe Useful Life Expectancy (SULE) Matrix

The SULE value generated by the below matrix gives an indication of the time a tree is expected to be usefully retained. Adapted from Barrell (2001).

	1 Long SULE	2 Medium SULE	3 Short SULE	4 Removal	5 Move or Replace
A	Tree that appear to be retainable at the time of assessment for >40 years with an acceptable degree of risk, assuming reasonable maintenance.	Tree that appear to be retainable at the time of assessment for 15 to 40 years with an acceptable degree of risk, assuming reasonable maintenance.	Tree that appear to be retainable at the time of assessment for 5 to 15 years with an acceptable degree of risk, assuming reasonable maintenance.	Trees which should be removed within the next 5 years.	Trees which can be readily moved or replaced.
B	Structurally sound trees located in positions that can accommodate for future growth.	Trees that may only live for 15-40 years.	Trees that may only live for another 5-15 years.	Dead, dying, suppressed or declining trees.	Small trees <5 (m) in height.
C	Trees that could be made suitable for retention in the long term by remedial tree care.	Trees that could live for more than 40 years but may be removed for safety or nuisance reasons.	Trees that could live for more than 15 years but may be removed for safety or nuisance reasons.	Dangerous trees because of instability or loss of adjacent trees.	Young trees less than 15 years old but over 5m in height.
D	Trees of special significance that would warrant extraordinary efforts to secure their long term retention.	Trees that could live for more than 40 years but may be removed to prevent interference with more suitable individuals or to provide for new planting.	Trees that could live for more than 15 years but may be removed to prevent interference with more suitable individuals or to provide for a new planting.	Dangerous trees because of structural defects.	
E		Trees that could be made suitable for retention in the medium term by remedial tree care.	Trees that require substantial remedial tree care and are only suitable for retention in the short term.	Damaged trees not safe to retain.	
F				Trees that could live for more than 5 years but may be removed to prevent interference with more suitable individuals or to provide for a new planting.	
G				Trees that are damaging or may cause damage to existing structures within 5 years.	

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Appendix B: Sustainable Retention Index Value (SRIV) Matrix

Age Class	Vigour Class & Condition Class					
	Good Vigour & Good Condition (GVG)	Good Vigour & Fair Condition (GVF)	Good Vigour & Poor Condition (GVP)	Low Vigour & Good Condition (LVG)	Low Vigour & Fair Condition (LVF)	Low Vigour & Poor Condition (LVP)
	Able to be retained if sufficient space available above and below ground for future growth. No remedial work or improvement to growing environment required. Retention potential – Medium- Long Term	Able to be retained if sufficient space available above and below ground for future growth. Remedial work may be required or improvement to growing environment may assist. Retention potential – Medium Term Potential for longer with remediation or more favourable environmental conditions.	Able to be retained if sufficient space available above and below ground for future growth. Remedial work unlikely to assist condition, improvement to growing environment may assist. Retention potential – Short Term. Potential for longer with remediation or more favourable environmental conditions.	May be able to be retained if sufficient space available above and below ground for future growth. No remedial work required, but improvement to growing environment may assist vigour. Retention potential – short Term. Potential for longer with remediation or more favourable environmental conditions.	May be able to be retained if sufficient space available above and below ground for future growth. Remedial work or improvement to growing environment may assist condition and vigour. Retention potential – Short Term. Potential for longer with remediation or more favourable environmental conditions.	Unlikely to be able to be retained if sufficient space available above and below ground for future growth. Remedial work or improvement to growing environment unlikely to assist condition or vigour. Retention potential – likely to be removed immediately or retained for Short Term. Potential for longer with remediation or more favourable environmental conditions.
Young (Y)	Index value 9 Retention potential – Medium – Long Term Likely to provide minimal contribution to local amenity if height <5m High potential for future growth and adaptability. Retain, remove or replace	Index value 8 Retention potential – Short –Medium Term. Potential for longer with improved environmental conditions. Likely to provide minimal contribution to local amenity if height <5m Medium-High potential for future growth and adaptability. Retain, remove or replace	Index value 5 Retention potential – Short Term. Potential for longer with improved environmental conditions. Likely to provide minimal contribution to local amenity if height <5m Low-medium potential for future growth and adaptability. Retain, remove or replace	Index value 4 Retention potential – Short Term. Potential for longer with improved environmental conditions. Likely to provide minimal contribution to local amenity if height <5m Medium potential for future growth and adaptability. Retain, remove or replace	Index value 3 Retention potential – Short Term. Potential for longer with improved environmental conditions. Likely to provide minimal contribution to local amenity if height <5m Low-Medium potential for future growth and adaptability. Retain, remove or replace	Index value 1 Retention potential – Likely to be removed immediately or retained for Short Term. Likely to provide minimal contribution to local amenity if height <5m. Low potential for future growth and adaptability
Mature (M)	Index value 10 Retention potential – Medium – Long Term	Index value 9 Retention potential – Medium Term. Potential for longer with improved environmental conditions.	Index value 6 Retention potential – Short Term. Potential for longer with improved environmental conditions.	Index value 5 Retention potential – Short Term. Potential for longer with improved environmental conditions.	Index value 4 Retention potential – Short Term. Potential for longer with improved environmental conditions.	Index value 2 Retention potential – Likely to be removed immediately or retained for Short Term
Over-mature (O)	Index value 6 Retention potential – Medium – Long Term	Index value 5 Retention potential – Medium Term	Index value 4 Retention potential – Short Term	Index value 3 Retention potential –Short Term. Potential for longer with improved environmental conditions.	Index value 2 Retention potential – Short Term	Index value 0 Retention potential – Likely to be removed immediately or retained for Short Term

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Appendix C: Tree table

Tree no	Botanical Name	Common Name	Height (m)	Canopy spread (radius m.)	DBH (m)	Age Class[1]	Health[2]	Structure[3]	SULE[4] / SRIV[5]	TPZ[6] (m)
1	*Ficus obliqua* var. *obliqua*	Small-leaved Fig	30	14 to 15	1.61	M	G	G	3A / MGVG-10	15
2	*Ficus obliqua* var. *obliqua*	Small-leaved Fig	32	8 to 12	1.64	M	G	G	3A./ MGVG-10	15
3	*Podocarpus elatus*	Plum Pine	20	4 to 7	0.72	M	G	G	3A / MGVG-10	10
4	*Angophora costata*	Smooth-barked Apple	10	3	0.22	EM	M	M	2A / MGVF-9	3
5	*Angophora costata*	Smooth-barked Apple	14	4	0.28	EM	M	M	2A / MGVF-9	4

Tree table legend:

1 **Age Class:** OM = Mature; M = Mature; EM = Early Mature

2 **Health:** G = good; M = moderate; F = fair

3 **Structure:** G = good; M = moderate; F = fair

4 **SULE:** Safe Useful Life Expectancy (see SULE matrix - Appendix A);

5 **SRIV:** Sustainable Retention Index Value (see SRIV matrix, Appendix B)

6 **TPZ:** Tree Protection Zone

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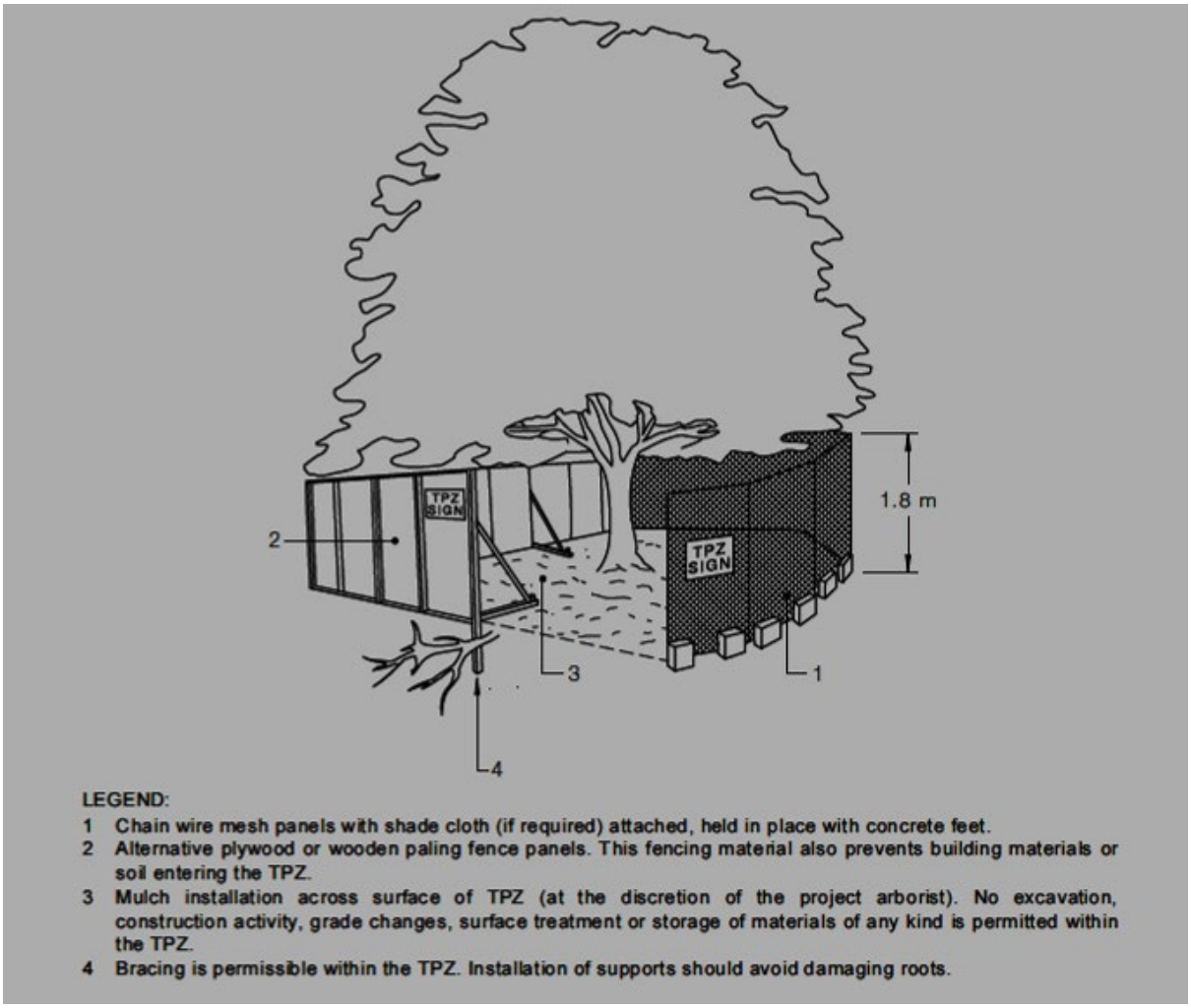
Appendix D Tree protection zone fence example



LEGEND:

1 Chain wire mesh panels with shade cloth (if required) attached, held in place with concrete feet.
2 Alternative plywood or wooden paling fence panels. This fencing material also prevents building materials or soil entering the TPZ.
3 Mulch installation across surface of TPZ (at the discretion of the project arborist). No excavation, construction activity, grade changes, surface treatment or storage of materials of any kind is permitted within the TPZ.
4 Bracing is permissible within the TPZ. Installation of supports should avoid damaging roots.

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Memorandum

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