Q. WHAT IS THE CRITICAL ISSUE WITH THE LAMAN STREET HILLS FIG TREES AND WHY CAN'T IT BE RESOLVED WITHOUT REMOVING THE TREES?

- **Root plate instability is the critical issue in Laman Street Hills Figs**
- **Branch failure is now also an increasing problem**

It is uncommon to have such very large trees in the confined environs typified by Laman Street. At nearly 24 metres height, the Laman Street Figs are the tallest street trees in Newcastle. Their increasing instability is a critical issue because their tall vertical branches are leveraging on linear root plates that are oriented perpendicular to the direction of the most common storm winds.

Branch stability is now a focus of concern as a result of recent branch failures during a moderate wind event.

As the trees grow taller the leverage on the restricted root plates is increasing and the trees are approaching the point of failure. That point of failure is now more likely to occur under less severe weather events than the June 2007 storm.

The trees' foundations (root plates) cannot be reinforced and made good at such a late stage of tree maturity. The universal approaches to managing large mature trees at significant risk of failure is to crown reduce and/or isolate the trees from targets or remove the trees.

Q. WHY ISN'T THERE ANY CERTAINTY ABOUT WHEN THE TREES IN LAMAN STREET WILL FAIL?

What we know:
We know the trees have defective root-plates. The failure over recent years of more than eight trees with defective root-plates as a major factor, serves as an alert that the condition is present and problematic.

What we don't know:
We cannot state with any degree of precision how much time is remaining for the Laman street Hills fig trees. The question of when the trees would be likely to fail or "how long have the trees got" cannot be answered with accuracy and can only be addressed in general terms; the literature supports this view:

Weber and Mattheck (2003) have this to say:

> *"it is extraordinarily difficult to answer this question….in the last two decades the authors have followed the fate of badly damaged trees, and have found that an accurate time prediction is not possible, even to within 5-10 years. An acutely dangerous tree may fall today or may stand for another 5-10 years, if it has not been scythed down by a strong enough gust of wind striking it from the right direction. Even statements like 'Still safe to stand for several years' (without crown pruning or mechanical aids!) are highly dubious. In common parlance, 'several years' can mean only a period from 2 to a maximum of 10 years. However, no tree failure can be dated with this time precision"*

The critical problems are the tree's asymmetric root-plate and crown architecture:

- Trench investigation in 2006 led to a conclusion that the root-plates of the trees are eccentric, not radial, and across one side at least did not conform to the theoretical ideal of root-plate development.
- The history of root severance in infrastructure maintenance and the planting environment suggests that the root-plates have developed mainly in a lineal configuration.
- The trees on the southern side of the street have few if any tensile roots to provide full anchorage against southerly winds, and only a very limited compression root-plate.
- The trees on the northern side have no tension root-plate as the kerb has deflected the tensile roots to run parallel to the kerb.
- The trees on the southern side of Laman Street could be said to be more vulnerable to wind-throw because their surface roots have been mechanically damaged over a period of decades.
- The historical evidence in Newcastle is that Hill's Figs with lineal root-plates and a history of root severance are more likely to fail under storm conditions than Hill's Figs with entire and radial root-plates.
- All of the tree crowns are asymmetric. This is a natural consequence of the short planting distance between the trees. Competition for light has lead to the development of branches where the greatest extension is towards the available light. Crown asymmetry in conjunction with root plate confinement and asymmetry is contributing to tree instability.

Q. THE LAMAN STREET HILLS FIG TREES HAVE SURVIVED MANY STORMS SO DOESN'T' THAT PROVE THEM SAFE?

It should never be assumed that a tree that survives a storm event is therefore 'safe'

The trees root system is not visible, and therefore the extent of root injury and mechanical failure induced by storm events is largely undetectable. The impact of numerous root injury events is therefore cumulative.

The next storm event may be the tipping point if the root damaged tree has had insufficient time, energy or if it lacks the space to produce adaptive root growth to counter a reduction in root system functionality. This is the situation Laman Street.

Along with numerous infrastructure events causing root injury, the Laman Street trees have been subject to numerous storms over their 70+ year life span. However it is only in recent years that their crowns have extended beyond the protective buffer of the library and Gallery and the wind load is now significant.

For the trees to remain stable, the stress load from the increased wind exposure has to be accommodated by a corresponding increase in mechanically functional roots in those areas under compressive and tensile forces. This adaptive growth cannot occur in Laman Street because of the confined root space. As a result the trees are growing toward failure in the near future.

Q WHAT DOES THE TECHNICAL LITERATURE HAVE TO SAY ABOUT ASSESSING TREE ROOT PLATE STABILITY IN STREET ENVIRONS?

The literature acknowledges the lack of research on asymmetric root plates and recommends case-book experience as a potential source of information.

- The case-book experience with Hill's Figs in Newcastle streets is that most of the trees have lineal root-plates and a history of ongoing root cutting and damage. The history shows that such trees begin to fail when around 70 years old.
- The Hills fig failures in Tyrrell Street in 2004 are incidences of whole tree failure due to lineal root-plate and associated root problems. The failures are an alert to the problem.
- An increase in the incidence of failures eg in Bruce Street and Laman Street 2007 is an indication that time is running out.

Q. IF ROOT PLATES ARE DEFECTIVE WHAT IS HOLDING THE TREES UP?

Based on all available information from investigations, practical experience, the case history and the literature, it is believed that a number of factors acting in concert are providing a measure of stability:

- **Sinker roots close to the base of the trunks**. Previous failures show that some trees had 'sinker' roots beneath the trunk. It is assumed but not verified that sinker roots may present in the Laman Street trees.
- **Root grafting** is known to occur across closely planted trees of the same species. It is assumed but not verified that grafting might be contributing to lineal stability but not to lateral stability.
- **Root slings and mechanical support from infrastructure.** The case history shows that roots do 'hook' under pipes and cables and do intertwine amongst in ground cables and pipes. Roots respond to localised contact stress when growing against solid objects such as concrete, brick and asphalt thus gaining a degree mechanical support from the bulk of the infrastructure. Since a tree measures and reacts to local environmental conditions, it will 'sense' stability if its roots have co-opted the support from infrastructure. In accordance with the 'Axiom of Uniform Stress' which states that the tree will not produce superfluous growth, the infrastructure supported tree is likely to produce less mechanically effective roots.
- **The planting site** may be providing a measure of stability by the constrictive effects of the surrounds on root development essentially wedging the tree root plate into a confined space
- **Crown mass** where the weight of the tree (c700kg per cubic metre) presses down on the root ball and surrounding soil resulting in friction and an increase in soil shear strength.
- **Wind buffering.** Until June 2007 the crowns of the trees were fully interdependent and the wind load was shared by the group. The loss of some individuals from the group after 2007 removed some of the group buffering capacity. We don't have data on existing wind patterns, pressures and velocities for Laman Street but we have had recent branch failures in 2011 in newly exposed trees on the south and north side of the street.

Q. WHY CAN'T WE HAVE A STAGED REPLACEMENT APPROACH?

In Laman Street it is the trees with the shortest remaining life expectancy dictate the outcome for the entire group. The shortest category is 4: tree will need to be removed within 5 years.

A north-south approach to tree removal and replanting is inadvisable.

- Removal of trees from the southern side while retaining the trees on the northern side would expose the northern trees to increased wind loads.
- The risk of windthrow of remaining trees will increase if the 'buffering' trees are removed.
- Removal of trees from the northern side would expose trees on the southern side to greater risk of wind-throw. The surface roots of the trees on the southern side have been directly exposed for many years to vehicle damage.

Q. WHY AREN'T PRUNING, CABLING & BRACING SUITABLE MANAGEMENT OPTIONS?

The root-plate is the primary defective part. Options for the management of the trees by:

- crown thinning or reduction pruning have been investigated and found impractical and unacceptable.
- An engineered cabling and bracing system has been investigated and found to be unacceptable.
- Lopping the trees back to a size small enough to resist windthrow has been investigated and found to be unacceptable.

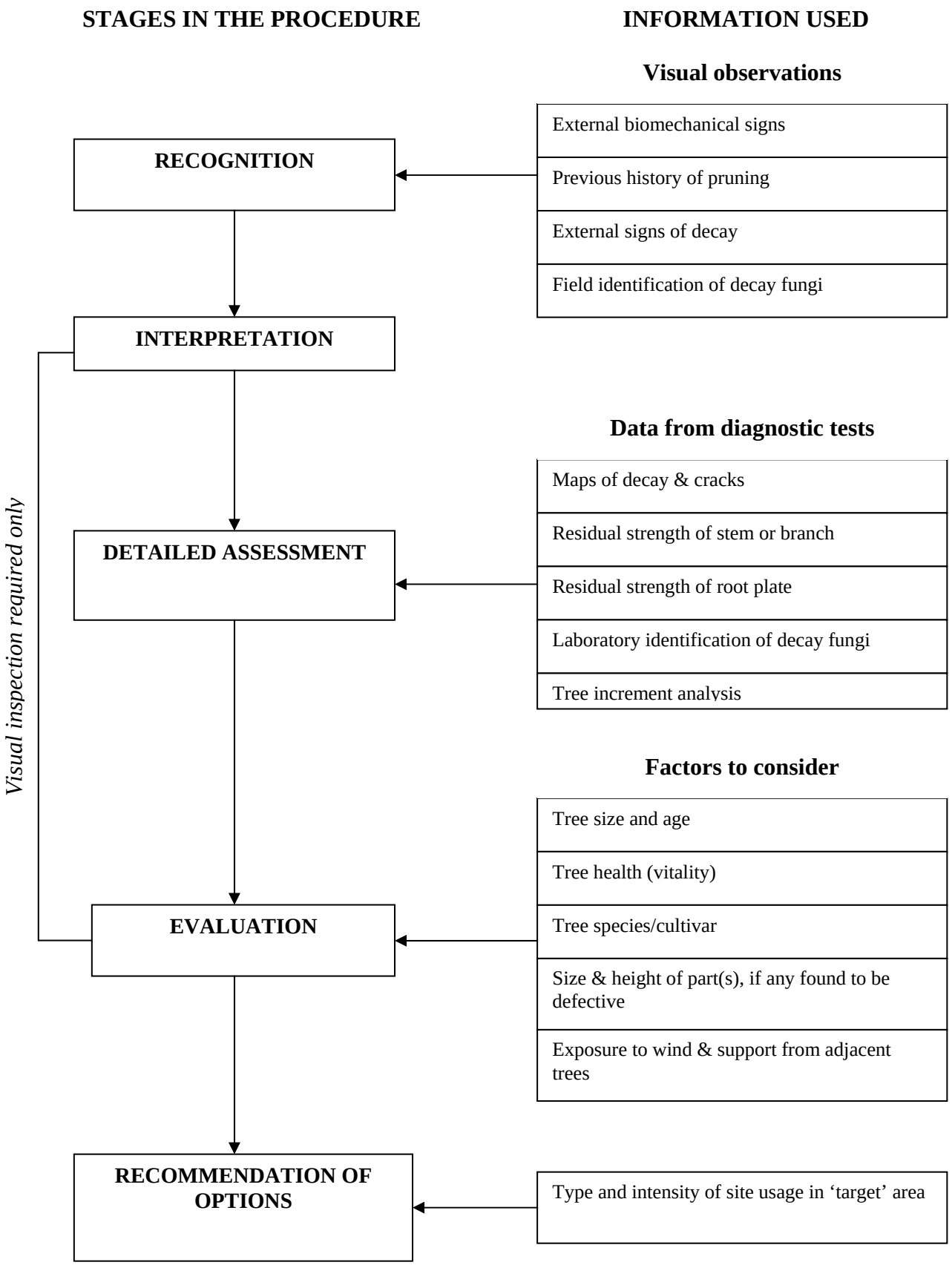
A SUMMARY OF NEWCASTLE HILLS FIG FAILURE CASE HISTORY

2002 Laman Street	Declining Port Jackson Fig with significant crown bias toward fountain and steps. major trunk and branch inclusions identified following Lonsdale assessment procedures and Mattheck VTA procedures. • Root system found to be crowded and confined to small planting pit • Tree shown to be too great a risk to retain and Council agrees to removal
2003 Tyrrell St	One Hills Fig failed in Beaufort Scale 10 storm, and One Hills Fig failed during excavation for infrastructure works – root sling Independent arborist J Fakes investigates and reports factors common to remaining trees in lower Tyrrell St: • limited roots of linear configuration • roots extremely compromised • significant weakness in the restricted root systems • severe root buttress damage from vehicles • branch inclusions • dense and uneven canopies • exposure to storm winds • greater exposure through removal of adjacent trees.
2004 Aukland St	Hills Fig structural root lineal entanglement with 11Kv underground cables: Impact of root removal assessed by City Arborist. Report peer reviewed by independent arborist S Slaytor: • Tree removed because structural root could not be cut without risk of tree failure over King Street intersection
2006 Laman Street	Investigations into: 1. structural root distribution for Art Gallery redevelopment proposal 2. primary and secondary branch stability 3. individual tree and group longevity Road pavement trenched to 1m depth at approx 2m from each of the Figs (ie theoretical edge of critical root plate) concluded: • eccentric primary woody roots and root plates • defective branch structure • south side trees provide wind buffer to north side trees • Figs would likely require removal within 5 to15 years.
2007 Laman Street & Bruce Street	Storm – East Coast Low – Beaufort Scale 12+ A total of five Hills Fig trees on the southern side of Laman Street experience root plate movement:

	Three of the trees on the southern side: • no compression side roots within the road pavement • tree tipped and sank approx 50mm below road surface level at the base of the trunk • fractures in the footpath pavement indicated root strain and flex on the tension side roots. • The trees did not return to their original position • All three trees assessed as an unacceptable risk and were removed One tree on the northern side: • no tension side roots found within the road pavement • root plate lifted away from the kerb creating a gap of approx 15mm wide and 1.5 m long indicating lack of tension root system • The tree did not return to it's original position • The severely asymmetric crown imposing the tree leveraging the tree assessed as an unacceptable risk and was subsequently removed. One tree on the northern side: • Root plate lifted 10 mm away from the kerb on the tension side • The tree returned to its original position and monitoring was commenced and finished after 8 weeks • Not further trunk/root plate movement was indentified Two Hills Fig trees in Bruce Street failed with one tree falling through the tree on the opposite side of the street: • Lifted root plate revealed sinker roots at the base of the trunk with the remainder of structural roots oriented parallel with kerb and road • No stabilising structural roots on the tension or compression side
2009 Laman Street	Investigations by independent arborist D Marsden: • Root plates are the main defective part of the trees • Recommends removal of the 14 Hills Figs as a group as the most practical option based on tree interdependency. • Review of options for risk mitigation by pruning, cabling or lopping. • All options rejected as impractical or unacceptable.
2010 Swan Street	Hills Fig whole tree collapse as a result of branch inclusions
2011 Laman Street	Three large branch failures as a result of a moderate wind event – one branch on the southern side and two on the northern side of the street

Attachments 1 to 3 are industry best practice approach to tree assessment and deciding options for remedial work.

1. Lonsdale's stages in the process of tree assessment,
2. Lonsdale's stages in the process of tree assessment applied to Laman St
3. Lonsdale's Options for Remedial work



Lonsdale, D. (1999) *Principles of Tree Hazard Assessment and Management* Forests Commission, The Stationery Office, London

STAGES IN THE PROCEDURE	INFORMATION USED
	Visual & other observations
RECOGNITION	2004 Fakes review of Tyrrell St Beaufort scale 10 storm failures. Utility root sling failure of Hills Fig in Tyrrell St. Fig removal due to root entanglement in 11 KV cables King St History of lopping induced branch inclusions, notch stress and cluster wedge formations Ganoderma root rot ID in Hills Fig Civic Park Stem inclusion failures in Hills Fig Civic Park 2007 storm failures in Laman Street
INTERPRETATION	
	Data from investigations
DETAILED ASSESSMENT	Marsden studies 2003, 2006, 2007, 2009. Trenching to the theoretical critical root plate found no structural roots in roadway. GPR not able to accurately identify root distribution in road or footway Literature review finds no data on root system studies in street environs - points to case history as basis for support in assessment. Reliable data on residual strength of root plate is not measurable at present. Current methodologies are experimental only. Severe crown asymmetry. Trees >22 m height. Crown spread >20 m on N/S axis and <10 on E/W axis. Increasing exposure to S, SW and SE winds. Southern trees buffer northern trees
	Factors to consider
EVALUATION	Trees are at late maturity stage of life cycle. Tree canopies are interlocked. Root grafting is possible but only in linear form. Severe linearity in root distribution which is perpendicular to prevailing wind. Hills Fig case history points to failure of root plate as most likely event. Incidence of branch failure is increasing. Options include lopping, closure of space, removal
RECOMMENDATION OF OPTIONS	High level site occupation and pedestrian usage provides critical ‘target’ area in times of severe weather ie Beaufort scale 9 and above.

Visual inspection required only

Lonsdale, D. (1999) *Principles of Tree Hazard Assessment and Management* Forests Commission, The Stationery Office, London

DECIDING OPTIONS FOR REMEDIAL WORK ON TREES

after Lonsdale (1999)